Museum Library QE 701 J8
PALEONTOLOGY LIBRARY DEC 13 1937

Volume 11 DECEMBER, 1937 Number 8

JOURNAL OF PALEONTOLOGY

A Publication of

The Society of Economic Paleontologists and Mineralogists

A Division of the American Association of Petroleum Geologists

and

The Paleontological Society

An Associate of the Geological Society of America

CONTENTS

Distinctive Foraminifera of the Genus *Marginulina* from Middle Tertiary Beds of the Gulf Coast ..... *J. B. Garrett and A. D. Ellis, Jr.* 629

Blastoids of the Osage Group, Mississippian: Part II. The Genus *Cryptoblastus* ..... *L. M. Cline* 634

Stratigraphy and Fauna of the Sacajawea Formation, Mississippian, of Wyoming ..... *C. C. Branson* 650

Foraminifera of the Middle Tertiary Carapita Formation of Northeastern Venezuela ..... *H. D. Hedberg* 661

The Fusulinid, *Wedekindellina*, in Mid-Pennsylvanian Rocks of Kansas and Missouri ..... *Norman D. Newell and Raymond P. Keroher* 698

New Occurrence of the Upper Carboniferous Crinoid Genera *Amphicrinus* and *Synerocrinus* ..... *L. R. Laudon* 706

Genotype Designations and New Names for Invalid Homonyms Among Paleozoic Gastropod Genera ..... *J. Brookes Knight* 709

PALEONTOLOGICAL NOTES

Textularia hockleyensis var. *malkinae* Coryell and Embich, a new name for *Textularia hockleyensis* var. *panamensis* Coryell and Embich ..... H. N. Coryell 714

JOURNAL of PALEONTOLOGY

RAYMOND C. MOORE AND C. WYTHE COOKE
Editors

ASSOCIATE EDITORS

JOSEPH A. CUSHMAN
Sharon, Massachusetts

G. DALLAS HANNA
San Francisco, California

CARL O. DUNBAR
New Haven, Connecticut

T. WAYLAND VAUGHAN
Washington, D.C.

The JOURNAL OF PALEONTOLOGY is published semi-quarterly by the Society of Economic Paleontologists and Mineralogists, a division of the American Association of Petroleum Geologists, and by the Paleontological Society, associated with the Geological Society of America.

The subscription price of the JOURNAL OF PALEONTOLOGY is $6.00 per year prepaid to addresses in the United States, Mexico, Cuba, Puerto Rico, Panama Canal Zone, Republic of Panama, Dominican Republic, El Salvador, Bolivia, Colombia, Honduras, Nicaragua, Peru, Hawaiian Islands, Philippine Islands, Guam, Samoan Islands.

Single numbers, $2.00 each.

Postage is charged extra: For Canada, 20 cents on annual subscriptions (total $6.20); for all other countries in the Postal Union, 40 cents on annual subscriptions (total $6.40).

The JOURNAL will furnish reprints at cost. Orders should accompany corrected galley proof.

Communications about the JOURNAL, subscriptions, rates, memberships, change of address, and non-receipt of preceding numbers should be addressed to Society of Economic Paleontologists and Mineralogists, P. O. Box 979, Tulsa, Oklahoma. Claims for non-receipt of preceding numbers must be sent in within three months of the date of publication in order to be filled gratis. Communications in regard to advertising should be addressed to Henry V. Howe, Louisiana State University, Baton Rouge, Louisiana.

Communications in regard to manuscripts or purely editorial matters should be addressed to Raymond C. Moore, University of Kansas, Lawrence, Kansas, or C. Wythe Cooke, U. S. Geological Survey, Washington, D.C.

Entered as second-class matter at the Post Office at Tulsa, Oklahoma, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in paragraph 4, section 538, P. L. and R., authorized April 3, 1935.

Additional entry as second-class matter at the Post Office at Menasha, Wis.

GEORGE BANTA PUBLISHING COMPANY, MENASHA, WIS.

JOURNAL OF PALEONTOLOGY

A Publication of
The Society of Economic Paleontologists and Mineralogists
A Division of the American Association of Petroleum Geologists
and
The Paleontological Society
An Associate of the Geological Society of America

VOLUME 11 DECEMBER, 1937 NUMBER 8

CONTENTS

PAGE

Distinctive Foraminifera of the Genus *Marginulina* from Middle Tertiary Beds of the Gulf Coast . *J. B. Garrett and A. D. Ellis, Jr.* 629

Blastoids of the Osage Group, Mississippian: Part II. The Genus *Cryptoblastus*. . . . . *L. M. Cline* 634

Stratigraphy and Fauna of the Sacajawea Formation, Mississippian, of Wyoming. . . . . *C. C. Branson* 650

Foraminifera of the Middle Tertiary Carapita Formation of Northeastern Venezuela . . . . . *H. D. Hedberg* 661

The Fusulinid, *Wedekindellina*, in Mid-Pennsylvanian Rocks of Kansas and Missouri. . . *Norman D. Newell and Raymond P. Keroher* 698

New Occurrence of the Upper Carboniferous Crinoid Genera *Amphicrinus* and *Synerocrinus* . . . . . *L. R. Laudon* 706

Genotype Designations and New Names for Invalid Homonyms Among Paleozoic Gastropod Genera . . . . . *J. Brookes Knight* 709

PALEONTOLOGICAL NOTES

Textularia hockleyensis var. *malkinae* Coryell and Embich, a new name for *Textularia hockleyensis* var. *panamensis* Coryell and Embich . . . . . *H. N Coryell* 714

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 8, PP. 629–633, PL. 86, DECEMBER, 1937

DISTINCTIVE FORAMINIFERA OF THE GENUS *MARGINULINA* FROM MIDDLE TERTIARY BEDS OF THE GULF COAST

J. B. GARRETT AND A. D. ELLIS, JR.

ABSTRACT

Marginulina mexicana Cushman is refigured and a new variety is described from the Gulf Coast. Three new species of *Marginulina* are described from Middle Tertiary strata of the Gulf Coast.

In the subsurface section of coastal Texas and Louisiana, several characteristic species of *Marginulina* occur in the 1,500 to 2,000 feet of strata lying above the Vicksburg Oligocene and below the *Heterostegina* zone (variously classified as middle Oligocene, upper Oligocene, and lower Miocene). The purpose of this paper is not to determine the exact age of the strata involved, but to describe and figure the most common and distinctive species of *Marginulina* occurring in them. All species treated are of considerable stratigraphic significance. In addition to figuring the three new species and one new variety described, it seems best for purposes of comparison to refigure *Marginulina mexicana* Cushman from the Meson formation of Mexico.

Concerning the new variety *Marginulina mexicana* var. *vaginata*, it may be pointed out that this has been referred by some workers to *Marginulina philippinensis* Cushman, a Recent species from the Philippine archipelago, which it resembles greatly in general appearance but from which it appears to differ in detail. Mr. James B. Dorr kindly loaned for examination a foraminiferal assemblage from the Meson formation, State of Vera Cruz, Mexico, which contained, in addition to numerous specimens of *Marginulina mexicana*, the following species common to the "*Marginulina* zone" of Texas and Louisiana:

Foraminifera and Ostracoda from the Meson formation of Vera Cruz

Textularia aff. *mississippiensis* Cushman
Robulus cf. *vaughani* (Cushman)
Lenticulina sp.
Marginulina howei Garrett and Ellis, n. sp.
Marginulina cf. *sublituus* Nuttall
Nodosaria vertebralis (Batsch)
Camerina sp.
Heterostegina sp. (*antillea?*)—abundant
Uvigerina sp. (finely costate)
Eponides cf. *antillarum* (d'Orbigny)
Miogypsina sp.
Cytheridea cf. *blanpiedi* Stephenson
Cythereis cf. *vicksburgensis* Howe and Law

Acknowledgments.—The writers are greatly indebted to Joseph A. Cushman for metatypes of *Marginulina mexicana* Cushman and *M. pulchra* Cushman, and for helpful advice. W. Storrs Cole kindly furnished specimens of species of *Marginulina* from the Meson of Mexico, and gave his opinions concerning them. James B. Dorr supplied Meson material, and discussed the species of *Marginulina* occurring in Mexico and the Gulf Coast. Eli T. Monsour also furnished material from the Meson. Helpful comments and criticism were provided by Henry V. Howe, M. C. Israelsky, and A. R. Mornhinveg.

SYSTEMATIC DESCRIPTIONS

Family LAGENIDAE Cushman
Subfamily NODOSARIINAE Cushman

Genus MARGINULINA d'Orbigny

MARGINULINA MEXICANA Cushman
Plate 86, figures 4*a*, 4*b*, 15*a*–16*b*

Marginulina mexicana CUSHMAN, *1925*, Cushman Lab. Foram. Research, Contr., vol. 1, pt. 3, p. 61, pl. 10, fig. 1.

The following description is quoted from Cushman:

Test elongate, compressed, especially in the earlier portion, early chambers close coiled, but soon becoming uncoiled, and the last two or three uniserial; chambers indistinct in the earlier portion, later ones becoming more distinct, inflated; sutures depressed; surface ornamented with a few sharp longitudinal costae, 10–12 in number, the last-formed chamber sometimes with more; aperture with a definite constricted neck.

Length up to 1 mm.

Type specimen (U. S. Nat. Mus., no. 353,679), from San Rafael formation, Huasteca R. R., km. post 9, 0.8 kms. east of Big Cut, Mexico, collected by T. Wayland Vaughan.

Dimensions of metatype (Louisiana State Univ. Mus., no. 1,901, from San Rafael formation, Huasteca R. R., km. post 9, 0.8 kms. east of Big Cut, Mexico): Length, 0.65 mm.; width, 0.28 mm.

Dimensions of hypotype (Louisiana State Univ. Mus., no. 1,902, from Meson formation, approximately 1,050 meters S. 50 degrees W. from Rancho Santa Rosa on east bank of Arroyo La Laja; or 1,800 meters N. 32 degrees E. from small village of Tinaja on east bank of Arroyo La Laja, State of Vera Cruz, Mexico): Length, 1.09 mm.; width, 0.27 mm.

Dimensions of hypotype (Louisiana State Univ. Mus., no. 1,903, from Meson formation, same locality as above): Length, 1.14 mm.; width, 0.28 mm.

The metatype specimen is worn and broken, but displays the distinctive features of the species.

MARGINULINA MEXICANA Cushman var. VAGINATA Garrett and Ellis, n. var.
Plate 86, figures 2, 10, 11*a*, 11*b*, 12, 17*a*, 17*b*

Test elongate, strongly compressed except in the final 1 to 3 chambers, which are inflated; consisting of 6 to 9 chambers and averaging 8, partly coiled in the early chambers, rapidly becoming uncoiled; sutures distinct, of clear material, depressed in the later portion; surface ornamented by 12 to 18 distinct longitudinal costae, averaging 16, costae usually well developed but not prominent; aperture central, terminal, with a distinct neck carrying annular costae, often faintly radiate.

Young specimens are compressed throughout and have fewer chambers; the aperture is located at the peripheral side of the apertural face, and lacks the annular costae.

Specimens which lived in an adverse near-shore environment show little coiling and in general are not typical in form; they are smaller, narrower, and have fewer chambers and longitudinal costae, the aperture is not centrally located and lacks the annular costae.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,904, from Stanolind Oil and Gas Company no. 1 H. H. Ford, Hastings field, Brazoria County, Tex., from core at 5,860–5,864 feet): Length, 1.11 mm.; diameter of final chamber, 0.32 mm.; width of base, 0.32 mm.; thickness, 0.20 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,907, from Stanolind Oil and Gas Company no. 1 W. B. Wooster, Hastings field, Brazoria County, Tex., from core at 5,784–5,788 feet): Length, 0.98 mm.; diameter of final chamber, 0.35 mm.; width of base, 0.32 mm.; thickness, 0.21 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,908, from Stanolind Oil and Gas Company no. 1 C. P. Williams, South Houston field, Harris County, Tex., from core at 4,674–4,681

feet): Length, 0.51 mm.; width, 0.31 mm.; thickness, 0.17 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,905, from Stanolind Oil and Gas Company no. 1 Laura D. Shaw, Hastings field, Brazoria County, Tex., from core at 5,279–5,287 feet): Length, 0.43 mm.; width, 0.21 mm.; thickness, 0.15 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,906, from Stanolind Oil and Gas Company no. 1 Laura D. Shaw, Hastings field, Brazoria County, Tex., from core at 5,279–5,287 feet): Length, 0.51 mm.; width, 0.22 mm.; thickness, 0.20 mm.

Remarks.—In its typical form *Marginulina mexicana* var. *vaginata* differs from *Marginulina mexicana* Cushman in being broader, especially in the initial portion, in having more and better developed longitudinal costae, and in being more inflated in the final portion. Also, microspheric specimens appear to be much more common in *M. mexicana* than in *M. mexicana* var. *vaginata*.

MARGINULINA IDIOMORPHA Garrett and Ellis, n. sp.
Plate 86, figures 5*a*, *b*, 6, 13, 14

Test elongate, consisting of 3 to 7 chambers and averaging 4, inflated in the initial chamber, compressed in the succeeding 1 to 3 chambers, inflated in the final one or more chambers; showing a tendency to coil in the early chambers, but immediately becoming uncoiled; sutures narrow, distinct, of clear material, depressed; surface ornamented by numerous fine distinct longitudinal costae, which are broken at the sutures; aperture at the end of a cylindrical neck with annular costae, faintly radiate; aperture varies from peripheral to central terminal.

The typical form consists of four chambers, the initial and final chambers being inflated. In some specimens the costae, especially in the early chambers, are broken into small nodelike rows. *Marginulina idiomorpha* often occurs with *Marginulina mexicana* var. *vaginata*, but is hardier, persisting both higher in the section and further toward the old shoreline.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,909, from Stanolind Oil and Gas Company no. 1 C. D. Brown, Hastings field, Brazoria County, Tex., from core at 5,560–5,565 feet): Length, 0.55 mm.; diameter of final chamber, 0.20 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,912, from Stanolind Oil and Gas Company no. 1 C. D. Brown, Hastings field, Brazoria County, Tex., from core at 5,560–5,565 feet): Length, 0.55 mm.; diameter of final chamber, 0.20 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,911, from Stanolind Oil and Gas Company no. 1 C. D. Brown, Hastings field, Brazoria County, Tex., from core at 5,560–5,565 feet): Length, 0.60 mm.; diameter of final chamber, 0.24 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,910, from Stanolind Oil and Gas Company no. 3 Sneed, Hastings field, Brazoria County, Tex., from core at 5,690–5,694 feet): Length, 0.57 mm.; diameter of final chamber, 0.18 mm.

MARGINULINA HOWEI Garrett and Ellis, n. sp.
Plate 86, figures 8*a*, *b*, 9, 18

Test elongate, slightly compressed, especially in the initial portion, periphery rounded, early chambers coiled and indistinct, rapidly becoming uncoiled, later chambers increasingly inflated, chambers 6 to 12 in number; sutures slightly oblique, of clear material, indistinct in the coiled portion, distinct and slightly depressed in the uncoiled portion; surface smooth; aperture radiate, slightly produced, at or near the periphery. The periphery in the coiled portion is slightly keeled in some specimens.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,916, from Stanolind Oil and Gas Company no. 3 Mary Duhon, Hackberry field, Cameron Parish, La., from core at 4,074–4,076 feet):

Length, 1.06 mm.; diameter, 0.35 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,917, from Stanolind Oil and Gas Company no. 3 Mary Duhon, Hackberry field, Cameron Parish, La., from core at 4,130–4,135 feet): Length, 1.66 mm.; diameter, 0.35 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,918, from Stanolind Oil and Gas Company no. 3 Mary Duhon, Hackberry field, Cameron Parish, La., from core at 4,130–4,135 feet): Length, 0.66 mm.; diameter, 0.31 mm.

MARGINULINA TEXANA Garrett and Ellis, n. sp.

Plate 86, figures 1*a*, 1*b*, 3*a*, 3*b*, 7

Test elongate, stout, consisting of 6 to 8 chambers, slightly coiled in the initial portion, rapidly becoming uncoiled; initial chamber inflated, succeeding chambers somewhat compressed, final chambers large, inflated; sutures indistinct in the coiled portion, depressed in the later portion; surface ornamented with 12 to 14 distinct high longitudinal costae which are more or less spinose in well-preserved specimens; aperture central, terminal, with a distinct neck carrying annular costae, faintly radiate. The coiled compressed portion is almost absent in some specimens.

Dimensions of holotype (Louisiana State Univ. Mus., no. 1,913, from Stanolind Oil and Gas Company no. B-1 Pipkin, Big Hill Prospect, Jefferson County, Tex., from core at 6,560–6,570 feet): Length, 0.87 mm.; maximum diameter, 0.37 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,914, from Stanolind Oil and Gas Company no. B-1 Pipkin, Big Hill Prospect, Jefferson County, Tex., from core at 6,560–6,570 feet): Length, 0.92 mm.; maximum diameter, 0.35 mm.

Dimensions of paratype (Louisiana State Univ. Mus., no. 1,915, from Stanolind Oil and Gas Company no. B-1 Pipkin, Big Hill Prospect, Jefferson County, Tex., from core at 6,560–6,570 feet): Length, 0.50 mm.; maximum diameter, 0.28 mm.

Remarks.—This species resembles *Marginulina pulchra* Cushman, but differs in being larger, stouter, and in having a more flattened initial portion.

REFERENCES

APPLIN, E. R., ELLISOR, ALVA C., and KNIKER, HEDWIG T., *1925*, Subsurface

EXPLANATION OF PLATE 86

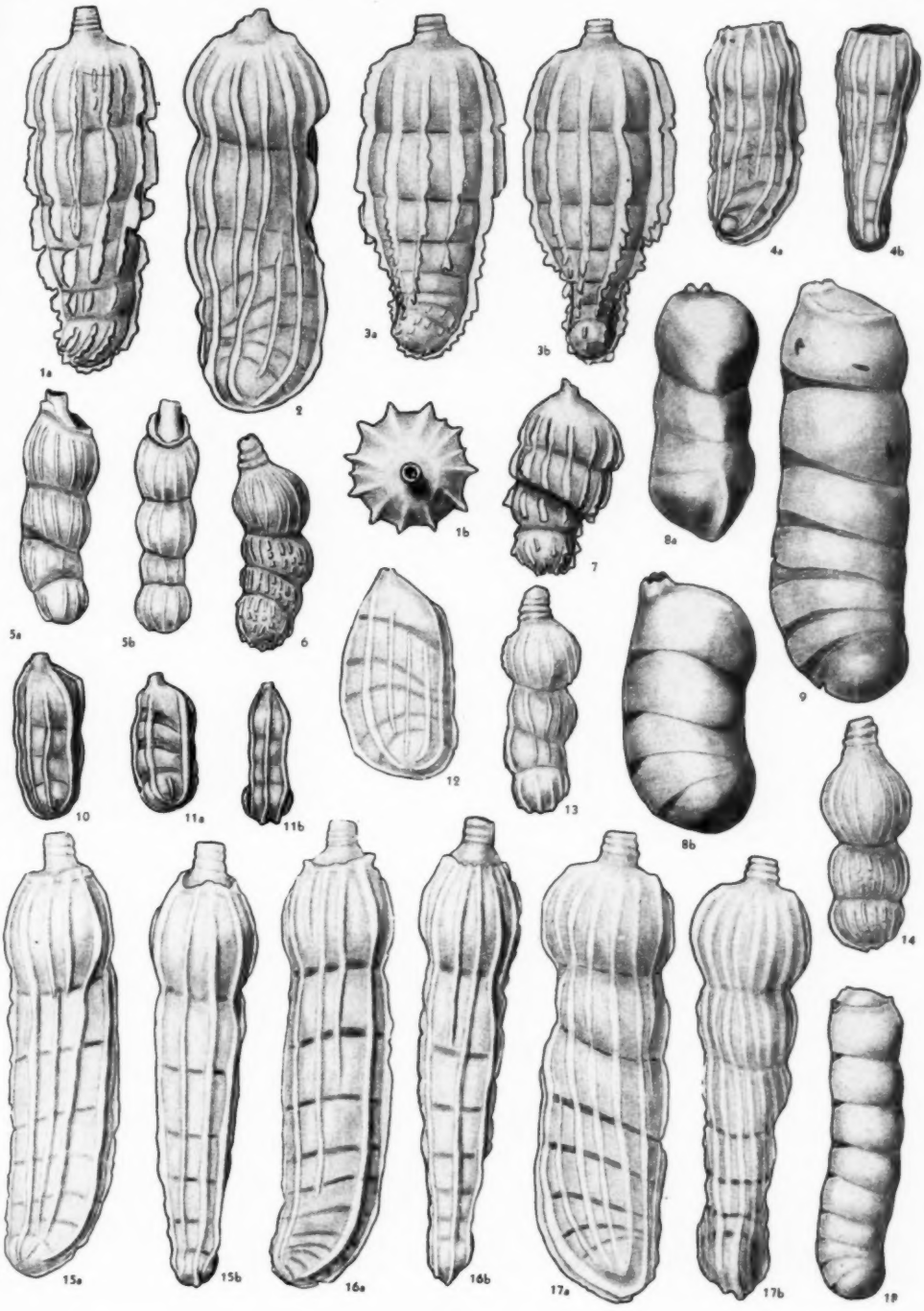
FIGS. *1a, 1b, 3a, 3b, 7—Marginulina texana* Garrett and Ellis, n. sp. *1a*, Side view; *1b*, apertural view, paratype no. 1, 914, ×56. *3a*, Side view; *3b*, front view, holotype, no. 1, 913, ×55. *7*, Side view, paratype no. 1,915, ×56, young specimen. Middle Tertiary, Texas. (p. 632)

2, 10, 11a, 11b, 12, 17a, 17b—Marginulina mexicana Cushman var. *vaginata* Garrett and Ellis, n. var. *2*, Side view, paratype no. 1,907, ×57, megalospheric form. *10*, Side view, paratype no. 1,906, ×46, dwarf specimen. *11a*, Side view; *11b*, front view, paratype no. 1,905, ×46, dwarf specimen. *12*, Side view, paratype no. 1,908, ×57, young specimen. *17a*, Side view; *17b*, front view, holotype no. 1,904, ×60, megalospheric form. Middle Tertiary, Texas. (p. 630)

4a, 4b, 15a–16b—Marginulina mexicana Cushman. *4a*, Side view; *4b*, front view, metatype no. 1,901, ×48. *15a*, Side view; *15b*, front view, megalospheric form, hypotype no. 1,902, ×57. *16a*, Side view; *16b*, front view, microspheric form, hypotype no. 1,903, ×60. Meson formation, Mexico. (p. 630)

5a, b, 6, 13, 14—Marginulina idiomorpha Garrett and Ellis, n. sp. *5a*, Side view; *5b*, front view, paratype no. 1,910, ×57. *6*, Side view, paratype no. 1,912, ×55. *13*, Side view, holtype no. 1,909, ×57. *14*, Side view, paratype no. 1,911, ×54. Middle Tertiary, Texas. (p. 631)

8a, b, 9, 18—Marginulina howei Garrett and Ellis, n. sp. *8a*, Front view; *8b*, side view, paratype no. 1,918, ×55, young specimen. *9*, Side view, holotype no. 1,916, ×55. *18*, Side view, paratype no. 1,917, very elongate specimen, ×26. Middle Tertiary, Louisiana. (p. 631)



Garrett and Ellis, Tertiary Foraminifera

UNIV. OF MICH.

stratigraphy of the Coastal Plain of Texas and Louisiana: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 9, pp. 79–122.

COLE, W. STORRS, and GILLESPIE, RUTH, *1930*, Some small Foraminifera from the Meson formation of Mexico: *Bull. Am. Paleontology*, vol. 15, no. 57b, p. 8, pl. 2, fig. 7.

CUSHMAN, J. A., *1921*, Foraminifera of the Philippine and adjacent seas: *U. S. Nat. Mus., Bull.* 100, vol. 4, p. 257.

———, *1925*, Mexican species of *Marginulina: Cushman Lab. Foram. Research, Contr.*, vol. 1, pt. 3, pp. 61, 62.

J. B. GARRETT AND A. D. ELLIS, JR., STANOLIND OIL AND GAS CO., HOUSTON, TEXAS. MANUSCRIPT RECEIVED BY THE EDITOR, MARCH 17, 1937. PUBLISHED WITH THE PERMISSION OF THE STANOLIND OIL AND GAS COMPANY.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 8, PP. 634–649, PLS. 87, 88, DECEMBER, 1937

BLASTOIDS OF THE OSAGE GROUP, MISSISSIPPIAN: PART II. THE GENUS *CRYPTOBLASTUS*

L. M. CLINE

ABSTRACT

Cryptoblastus is compared with allied genera and an emended generic diagnosis is offered. New information regarding the morphology of the genus has resulted from study of thin sections and polished surfaces. Special attention is directed to geographic and stratigraphic distribution of the Osage species. Nine species and varieties occurring in the Osage, four of them new, are described and illustrated.

This is the second of a series of papers (Cline, 1936) dealing with blastoids of the Osage group, of Mississippian age, of North America. No claims to completeness in these studies are made because many type specimens have been lost or are not available for study. The common forms of *Cryptoblastus* are well represented, however, in collections which I have studied at the State University of Iowa (which contains duplicate material of the Springer echinoderm collection), a large collection made by L. R. Laudon, and many specimens collected by myself.

Acknowledgments.—I am indebted to Dr. A. K. Miller for advice and many friendly criticisms offered while I was a graduate student at the State University of Iowa, and more recently for his generous loan of specimens. I wish to thank Dr. L. R. Laudon of the University of Tulsa for the loan of many carefully collected specimens. Thanks are also due the Graduate College of Iowa State College for funds to assist me in my field work.

SYSTEMATIC DESCRIPTIONS

Genus CRYPTOBLASTUS Etheridge and Carpenter, 1886

When Owen and Shumard (1852) republished their descriptions of *Pentremites* [*Orbitremites*] *norwoodi* and *Pentremites* [*Cryptoblastus*] *melo* they stated in a footnote that "It is probable that this [*O. norwoodi*] and the following [*C. melo*] species will constitute a new genus." In 1861 (p. 142) Meek and Worthen said of *Pentremites melo* and *Pentremites projectus:*

> Both these forms differ from the typical species of the genus *Pentremites* in having each pair of ovarian openings [the spiracles] distinctly separated, instead of closely united, with merely a thin septum between . . . they constitute a subgenus of *Pentremites*, occupying a position between the typical forms of that genus and *Nucleocrinus.*

But after having clearly outlined the above generic characters, Meek and Worthen failed to propose a name for their subgenus. *Pentremites melo* was referred to *Schizoblastus* when Etheridge and Carpenter (1882, p. 243) established that genus, although they later removed it from *Schizoblastus* (1886, p. 232) and made it the type of a new genus, *Cryptoblastus.* Etheridge and Carpenter recognized four species of *Cryptoblastus*, all from Mississippian rocks of North America: *Elaeacrinus? kirkwoodensis* Shumard, *Pentremites melo* Owen and Shumard, *Pentremites? melo* var *projectus* Meek and Worthen, and *Granatocrinus pisum* Meek and Worthen.

Since the founding of the genus only three additional species have been re-

ferred to it; in 1900 (pp. 246, 251) Rowley listed *Cryptoblastus concinnulus* and *Cryptoblastus?* sp. from the Burlington limestone at Louisiana, Mo., and Peck (1929, p. 245) has referred *Pentremites roemeri* Shumard to *Cryptoblastus*. Peck states that there are five other species of the genus in the Chouteau, but he does not list them.

In the present paper I am referring five additional species to *Cryptoblastus: Pentremites* (*Granatocrinus?*) *granulosus* Meek and Worthen, *Granatocrinus shumardi* Meek and Worthen, *Cryptoblastus melo* var. *cancellatus* Cline, n. var., *Cryptoblastus melo* var. *calcaratus* Cline, n. var., and *Cryptoblastus rowleyi* Cline, n. sp. *Grantocrinus exiguus* Rowley and Hare, also, is probably a *Cryptoblastus*. Several species of blastoids described by Rowley (and by Rowley and Hare) probably belong to *Cryptoblastus*, but it is not possible to determine this from the published illustrations and brief descriptions. The types are not now available.

Diagnosis of Cryptoblastus.—The following emended generic diagnosis is proposed for *Cryptoblastus*.

Calyx subglobose, ovoid, or elliptical. Summit contracted. Base generally concave but may be flat or even slightly protuberant. Basals small, as a rule, invisible laterally. Radials long, reaching considerably more than one-half height of calyx. Deltoids short, not prominent in lateral view. Upper ends of radials rest upon and overlap the truncated lower ends of deltoids. Ambulacra narrow, linear, reaching almost length of theca. Adoral portion of lancet exposed but width of exposed portion decreases aborally and near lower end almost or quite overlapped by side-plates. Lancet separated from radials by an hydrospire-plate which does not extend above radio-deltoid suture. Hydrospire pores formed by notches in hydrospire-plate and inner wall of adjacent radial; pores absent above radio-deltoid suture since hydrospire-plate does not extend above that, although in one species, *C. shumardi*, ambulacral pores are prominent and serve the function of hydrospire-pores. Hydrospire-plates formed by upper ends of inner walls of hydrospire folds. Four hydrospire folds beneath each ambulacrum, grouped in pairs, two to a side. Eight small spiracles (the posterior pair coalesce with the anus), each excavated chiefly in the lateral edge of a deltoid near its apex, the gap being closed by side plates and the lancet. In complete individuals peristome closed by an integument of numerous small irregular plates.

Remarks.—Cryptoblastus is related to *Carpenteroblastus, Lophoblastus, Nucleocrinus, Mesoblastus, Heteroblastus, Orbitremites, Acentrotremites, Nymphaeoblastus*, and *Schizoblastus*. Of these genera, only *Schizoblastus* is common in North America. It differs from *Cryptoblastus* in having no hydrospire-plate, in the presence of ambulacral pores both above and below the radio-deltoid suture, and in that the deltoids usually overlap and rest upon the upper edges of the radials. Generally the deltoids are short in *Cryptoblastus* and long in *Schizoblastus*.

Distribution of Cryptoblastus.—*Cryptoblastus* is restricted to Mississippian beds in North America. According to Peck (1929, p. 245), it is the most abundant blastoid in the Chouteau limestone (upper Kinderhook) of Missouri, being represented in that formation by six species. *Cryptoblastus* is common throughout the Burlington limestone, being particularly abundant in the lower part of the formation. *C. melo* (Shumard) *sensu lato* is the most common Burlington blastoid (with the possible exception of *Orbitremites norwoodi* which occurs characteristically in the upper part of the formation), and it has long been considered an index fossil of that formation. *C. granulosus* occurs in the upper Burlington, in the Keokuk, and, according to Moore (1928, p. 248), it ranges up into the Warsaw. *Elaeacrinus kirkwoodensis* Shumard of the St. Louis limestone of Missouri may possibly belong to *Crypto-*

blastus, but I have not been able to obtain a specimen for study.

CRYPTOBLASTUS MELO (Owen and Shumard) *sensu lato*

Pentremites melo OWEN and SHUMARD, *1850*, Acad. Nat. Sci. Philadelphia, Jour., vol 2, pt. 1, pp. 65, 66, pl. 7, figs. 14*a–c*.—*1852*, in D. D. Owen's "A geological survey of Wisconsin, Iowa, and Minnesota," p. 592, pl. 5*a*, figs. 14*a–c*.—ROEMER, *1852*, Archiv. für Naturgeschichte, Jahrb. 17, Band 1, pp. 391, 392.—HALL, *1862*, New York State Cab. Nat. Hist., Ann. Rept. 15, p. 146.—HAMBACH, *1884*, St. Louis Acad. Sci., Trans., vol. 4, no. 4, p. 545.—GREGER, *1934*, St. Louis Acad. Sci., Trans., vol. 28, no. 3, p. 162.

Pentremites melo var. *projectus* MEEK and WORTHEN, *1861*, Acad. Nat. Sci. Philadelphia, Proc., p. 142.—GREGER, *1934*, St. Louis Acad. Sci., Trans., vol. 28, no. 3, p. 162.

Elaeacrinus melo SHUMARD, *1863*, St. Louis Acad. Sci., Trans., vol. 2, no. 1, p. 112.—GREGER, *1934*, St. Louis Acad. Sci., Trans., vol. 28, no. 3, p. 132.

Granatocrinus melo MEEK and WORTHEN, *1866*, Illinois Geol. Survey, vol. 2, p. 275 (footnote).—SHUMARD, *1866*, St. Louis Acad. Sci., Trans., vol. 2, p. 375.—MEEK and WORTHEN, *1869*, Acad. Nat. Sci. Philadelphia, Proc., p. 84.—WACHSMUTH and SPRINGER, *1887*, Acad. Nat. Sci. Philadelphia, Proc., p. 3.

Granatocrinus melo var. *projectus* SHUMARD, *1866*, St. Louis Acad. Sci., Trans., vol. 2, p. 375.

Granatocrinus projectus MEEK and WORTHEN, *1868*, Illinois Geol. Survey, vol. 3, pt. 2, p. 496, pl. 18, fig. 7 (and probably fig. 6*a*).—GREGER, *1934*, St. Louis Acad. Sci., Trans., vol. 28, no. 3, p. 136.

Schizoblastus melo ETHERIDGE and CARPENTER, *1882*, Annals. and Mag. Nat. Hist., 5th. ser., vol. 9, p. 246.

Schizoblastus (*Granatocrinus*) *melo* WACHSMUTH, *1886*, Davenport Acad. Nat. Sci., Proc., vol. 4, p. 80.

Cryptoblastus melo ETHERIDGE and CARPENTER, *1886*, Catalogue of the Blastoidea, pp. 232–234, pl. 7, figs. 14, 15.—KEYES, *1894*, Missouri Geol. Survey, vol. 4, pt. 1, p. 139, pl. 18, figs. 7*a*, *b*.—KEYES and ROWLEY, *1897*, Iowa Acad. Sci., Proc., vol. 4, p. 32.—WELLER, *1898*, U. S. Geol. Survey, Bull. 153, p. 196.—BATHER, *1899*, The species of Blastoidea, pp. 8, 9.—ROWLEY, *1900*, Am. Geologist, vol. 26, pp. 245–247; *1905*, Am. Geologist, vol. 35, pp. 301, 302, pl. 21, figs. 2, 3; *1907*, Missouri Bur. Geology and Mines, 2d. ser., vol. 8, p. 40.—VAN TUYL, *1925*, Iowa Geol. Survey, vol. 30, p. 124, pl. 4, figs. 5, 6.—GREGER, *1934*, St. Louis Acad. Sci., Trans., vol. 28, no. 3, p. 131.

Cribroblastus melo HAMBACH, *1903*, St. Louis Acad. Sci., Trans., vol. 13, p. 40.—GREGER, *1934*, St. Louis Acad. Sci., Trans., vol. 28, no. 3, p. 130.

Cribroblastus projectus GREGER, *1934*, St. Louis Acad. Sci., Trans., vol. 29, no. 3, p. 130.

Cryptoblastus melo presents the same problem that arises in connection with *Schizoblastus sayi* and *Orbitremites norwoodi*, namely, that the species varies greatly in shape. This variation has been noted by several previous workers. Owen and Shumard, who first described the species (1850, pp. 65, 66), state that "the form of this pentremite is globular, sometimes slightly elongated." When Etheridge and Carpenter (1886) made it the genotype of *Cryptoblastus*, they described the calyx as "subglobose, or elongate-globular." Wachsmuth (1886, p. 80) stated that

> *Schizoblastus* (*Granatocrinus*) *melo* O. and Shum. is in its younger stage elongate-ovate, in medium sized specimens subglobose to globose, and in large specimens depressed globose. The same modifications, but perhaps not quite so marked, take place in *Granatocrinus norwoodi* O. and Shum. and in *Schizoblastus* (*Granatocrinus*) *sayi* Shum.

After studying a large number of representatives of *Cryptoblastus melo* from the lower Burlington limestone at Louisiana, Mo., Rowley (1900, p. 246) said:

> this blastoid varies quite a great deal in the character of the ornamentation, size, shape, and in the size of its basal plates and in the depth of the basal concavity.

He recognized several forms of the species, as can be seen from his statements:

> The variety with a large flat base approaches *Cryptoblastus projectus*. A very rare variety is constricted at the top of the radials or fork pieces and again at an equal distance above the base, giving an appearance not unlike that of a beer keg:

In reference to Wachmuth's statement that the calyx in this species

is in its younger stage elongate-ovate, in medium sized specimens subglobose to globose, and in large specimens depressed globose,

Rowley said

the statement that the young of granatocrinid blastoids are elongate while the adults are globose will hardly hold, as an extensive collection of any Burlington species will show.

There are over 200 specimens in my collection that can readily be identified as *Cryptoblastus melo* (Owen and Shumard) *sensu lato*, yet they differ considerably in size and shape. The height-to-width ratio varies considerably. I agree with Rowley that Wachmsuth's statement that the younger forms are elongate and the adults globose will not hold. It is true that a small variety of *C. melo*, which I have named *C. melo* var. *cancellatus*, is the most elongate of the varieties of *C. melo* and in average size the smallest, but some young individuals of *C. melo* var. *melo* are as small as *C. melo* var. *cancellatus*, still they are more nearly globular, and the proportions of the calyx are the same in larger individuals. There is good evidence that some of the varieties of *C. melo* occurring in the upper lower Burlington developed from forms characteristic of lower levels of the same formation. For example, the variety *cancellatus* is abundant in a zone near the base of the formation and seemingly it gave rise to the variety *calcaratus*, a larger and more ornate variety occurring stratigraphically higher in the Burlington.

CRYPTOBLASTUS MELO (Owen and Shumard) var. MELO Cline, n. var.[1]

Plate 87, figures 1–10

Pentremites melo OWEN and SHUMARD, *1850* (part), Acad. Nat. Sci. Philadelphia, Jour., vol. 2, pt. 1, pp. 65, 66, pl. 7, figs. 14*a–c; 1852* (part), Geol. Survey of Wisconsin, Iowa, and Minnesota, p. 592, pl. 5*a*, figs. 14*a–c*.

Schizoblastus melo ETHERIDGE and CARPENTER, *1882* (part), Annals and Mag. Nat. Hist., 5th ser., vol. 9, p. 246.

Cryptoblastus melo ETHERIDGE and CARPENTER, *1886* (part), Catalogue of the Blastoidea, pp. 232–234, pl. 7, figs. 14, 15. —KEYES, *1894*, Missouri Geol. Survey, vol. 4, pt. 1, p. 139 (part), pl. 18, figs. 7*a*, *b*.—ROWLEY, *1900* (part), Am. Geologist, vol. 26, pp. 245–247.—(?) VAN TUYL, *1925*, Iowa Geol. Survey, vol. 30, pl. 4, figs. 5, 6.

Calyx subglobular, slightly higher than wide; nine undeformed calices average 11.5 mm. high and 10.9 mm. wide, the largest one measuring 13.5 mm. high and the smallest 9.5 mm. high. Transverse section slightly decagonal due to depressed ambulacra and longitudinal interradial grooves. Keg- or barrel-shaped in lateral view, the sides being convex and the ends truncated. Periphery equatorial. Summit flat or gently concave. Base concave centrally but radial lips protrude slightly to form a low quinquepod.

Basalia small, roughly pentagonal, resting in a concavity so as to be hidden in a side view; maximum observed diameter of basalia 3.5 mm.; diameter of stem-base slightly more than one-half that of basalia. Azygous basal quadrate, paired basalia twice as large and broadly pentagonal.

Radials large, forming most of calyx. Radial bodies short, turned under and invisible from side; limbs reaching almost height of calyx, apparently truncated above by deltoids—this truncation is only apparent for in the genus the radials rest on the beveled lower edges of the deltoids. Inner part of limb elevated into a narrow ridge bordering the ambulacrum; aborally each ridge slopes abruptly down to ambulacrum but adorally the slope is more gentle and the ridge migrates away from the ambulacrum; near its upper extremity the ridge

[1] A fairly complete synonymy of *C. melo* is given under the discussion of *C. melo* (Owen and Shumard) *sensu lato*, so in the synonymy of each described variety few references to mere fossil lists are made because it is impossible to tell what variety the writer was dealing with. Exceptions are made where I have examined the specimens or where the list was compiled by the original nomenclator of the species.

again approaches the ambulacrum. Interradial sutures lie in deep longitudinal depressions. Radial ornamentation consists of three or four roughly parallel discontinuous longitudinal rows of nodes; along lower part of limb the rows are directed slightly toward the ambulacrum and inner rows may terminate at sinus, but along upper portion of limb the outer rows are directed away from sinus. Around each radial lip a groove borders the ambulacral ridge but it decreases in prominence upward. Some well-preserved specimens have one or two very fine lirae lying in the interradial groove. An additional feature seen in some specimens is a pair of grooves extending upward from base of limb, at first close to the interradial groove but upward approaching the ambulacrum and ending just outside the ambulacral ridge; where it crosses the groove outside the ambulacral ridge a small pit-like depression is formed whose position varies, but is usually located about three-fifths the height of calyx.

Deltoids reaching about one-seventh length of calyx measured around outside, narrowly triangular in outline; apex constricted to allow for spiracles, giving the apex the outline of a spear-head. Only lower ends of deltoids visible in lateral view; deltoids comprise less than one-half of oral view. Lateral borders sharply elevated from radio-deltoid suture upward to height of spiracles and connected below the spiracles by several transverse ridges. In unweathered individuals radio-deltoid sutures obtusely V-shaped (apex making an angle of about 135 degrees) and aborally directed, but a small amount of weathering changes the shape perceptibly; one of the most common resulting shapes is a brace with the salient pointing aborally.

Ambulacra expanding gradually adorally to radio-deltoid suture, but above narrowing gradually; at height of this suture they comprise about one-half circumference of calyx, but at periphery they total only about one-fourth the circumference. Lower ends level with radial ridges but at about one-third the height of radial limbs they become depressed below these ridges and are distinctly depressed below the deltoids.

Lancet wider than thick, perforated by a small subcentral longitudinal canal; width gradually expands to height of radio-deltoid suture but becomes narrower above. Ambulacral groove deeply impressed, wider above than below. Distally the side-plates overlap the lancet, but proximally it is exposed and at radio-deltoid suture the exposed portion equals two-sevenths width of ambulacrum. About 45 side-plates to a row (or about 90 per ambulacrum) and, according to the original description, subhexagonal in outline; arranged so that sutures formed by adjacent plates are directed slightly adorally. Side-plates rest in depressions on the lancet; inner edges crenulated; handles resting on and concealing the hydrospire-plate. Outer side-plates small and apparently wedge-shaped. Contact of hydrospire-plate with lancet is sharp, but its junction with the radial limb can be discerned only with difficulty. Hydrospire pores small and absent above the radio-deltoid suture(this one character was considered by Etheridge and Carpenter to be of generic significance).

Spiracles formed chiefly by notches in edges of deltoids but bounded on one side by the lancet. The upper edges of the outer hydrospire walls end beneath and against the radials; the upper edges of the inner walls are known as the hydrospire-plates. The hydrospire folds extend the length of the ambulacrum but the four beneath each field become reduced to two (one to a side) near the distal ends. Anus large, subcircular, and protected posteriorly by a raised portion of the posterior deltoid.

Peristome unknown; probably covered in complete specimens.

Remarks.—The height-to-width ratio in this species seems to be about 11.5/10.9 regardless of size. The measurements given by Owen and Shumard in the original description (1850, pp. 65, 66)

were: height 6.5 lines, width 6 lines; and their illustrated specimen agrees with these measurements. Accordingly, I hereby designate the specimen figured by Owen and Shumard (1850, their pl. 7, figs. 14*a-c*) as the holotype of *Cryptoblastus melo* var. *melo*, and it automatically becomes the genotype of *Cryptoblastus*. My description of *C. melo* var. *melo* is based partly on the description and illustrations of the holotype by Owen and Shumard (though they were evidently dealing with more than one variety, for they state that "the form of this pentremite is globular, sometimes slightly elongated") and partly on 27 hypotypes in my collection.

C. melo var. *melo* is distinguished from allied varieties by its average size, a height-to-width ratio of 11.5/10.9, and by its surface ornamentation. *C. melo* var. *cancellatus* is smaller, but has a more elongate calyx, and has reticulate ornamentation on the lower part of the calyx.

Occurrence.—The holotype came from the Burlington limestone at Burlington, Iowa. The specimens in my collection came from the lower part of the Burlington at the type section, and from the lower Burlington limestone in the quarries of the Universal Atlas Portland Cement Company at Hannibal, Mo. In the quarries at Hannibal the species occurs in what appears to be the *Orophocrinus stelliformis* zone of Rowley, which comes just below the "white ledge" of northeastern Missouri.

Types.—Location of holotype unknown. Hypotypes, Univ. Iowa, 3,261 and 767–775, inclusive.

CRYPTOBLASTUS MELO (Owen and Shumard) var. CANCELLATUS Cline, n. var.

Plate 88, figures 17–20

Schizoblastus (*Granatocrinus*) *melo* WACHSMUTH, *1886* (part?), Davenport Acad. Nat. Sci., Proc., vol. 4, p. 80.

Cryptoblastus melo ROWLEY, *1900* (part?), Am. Geologist, vol. 26, pp. 245, 246, 247.

Calyx small, subovate, higher than wide; seven undeformed calices average 10.5 mm. high and 8.4 mm. wide; the largest specimen is 11.6 mm. high, the smallest 9 mm. high. Transverse section subcircular to decagonal. Lateral profile subovoidal, larger above than below. Periphery located distinctly above equator. Summit almost flat, contracted. Base contracted more than summit and distinctly truncated.

Basals as in *C. melo* var. *melo;* diameter of stem-base about one-half that of basals.

The major features of radial ornamentation as in the variety *melo*, but one characteristic feature is a series of transverse elevations and depressions confined to the lower portions of the radials which give it a reticulate pattern. The variety name *cancellatus* is given to call attention to this grid-like pattern.

Deltoids small; adoral borders finely crenulated; lateral edges bordered by nodose ridges which are connected below the spiracles by three or four similar transverse ridges.

Ambulacra level with adjacent longitudinal radial ridges upward to height of equator but above they become depressed below level of radials and deltoids. Hydrospire-plate perforated by 60 or 70 pores, two for each side-plate. Hydrospires as in the variety *melo*.

Remarks.—*C. melo* var. *cancellatus* can usually be distinguished from other varieties of the species by its smaller average size, its height-to-width ratio, and its radial ornamentation. The variety *melo* is occasionally of small size, but *cancellatus* differs from it in having a relatively greater height; the height-to-width ratio in *melo* is 11.5/10.9 and in *cancellatus* it is 10.5/8.4. Another characteristic, which it shares with *C. melo* var. *calcaratus*, is the reticulate ornamentation on the lower part of the radials. The periphery in *C. melo* var. *cancellatus* is distinctly above the equator in contrast to the equatorial periphery of *C. melo* var. *melo*.

Occurrence.—This variety ranges from the base to the top of the lower Burlington limestone, occurring most abundantly near the base of the formation. In Missouri it is abundant in the basal

part of the Burlington in the Marblehead Quarry at Louisiana, and it occurs sparingly in the basal Burlington one-half mile west of Newark. In Iowa it has been found in the lower Burlington limestone at Burlington, and one specimen came from the top of the lower Burlington east of Morning Sun from what Laudon calls the *Macrocrinus* zone (see Cline, 1936, p. 262).

Types.—Univ. Iowa; holotype, 766; paratypes, 763–765 and 3,262.

CRYPTOBLASTUS MELO (Owen and Shumard) var. CALCARATUS Cline, n. var.
Plate 87, figures 11–16

Calyx moderate in size, subovate, higher than wide; average height 12.6 mm.; average width 10.7 mm.; the largest undeformed specimen is 14.0 mm. wide. Transverse section subdecagonal. In lateral outline subovoidal, larger above than below, truncated at base. Periphery a little above equator. Summit flat, or very slightly concave; contracted. Base concave centrally, smaller than summit. Radial lips protruding and slightly flaring laterally.

Each radial limb ornamented with several longitudinal rows of nodes so closely spaced below as to effect a raised ridge but upward becoming more irregularly spaced, although larger and more wart-like; some rows begin at base of limb, others at interradial sutures, but all are directed toward the sinus as they are traced upward. Lower portions of radials marked by transverse elevations which unite with the longitudinal rows of nodes to produce a reticulate pattern. This ornamentation is not as pronounced as in *C. melo* var. *cancellatus*.

Deltoid ornamentation varies widely among individuals and the degree of weathering influences it appreciably. The holotype is marked by irregular wart-like elevations forming an intricate pattern not precisely like that of my other specimens; the posterior deltoid has an elevated median portion bordered by lateral elevations roughly paralleling the lateral edges, and just above the radio-deltoid suture a transverse elevation slopes steeply down to the suture, the slope being occupied by elongate nodes. Ornamentation on other deltoids

EXPLANATION OF PLATE 87

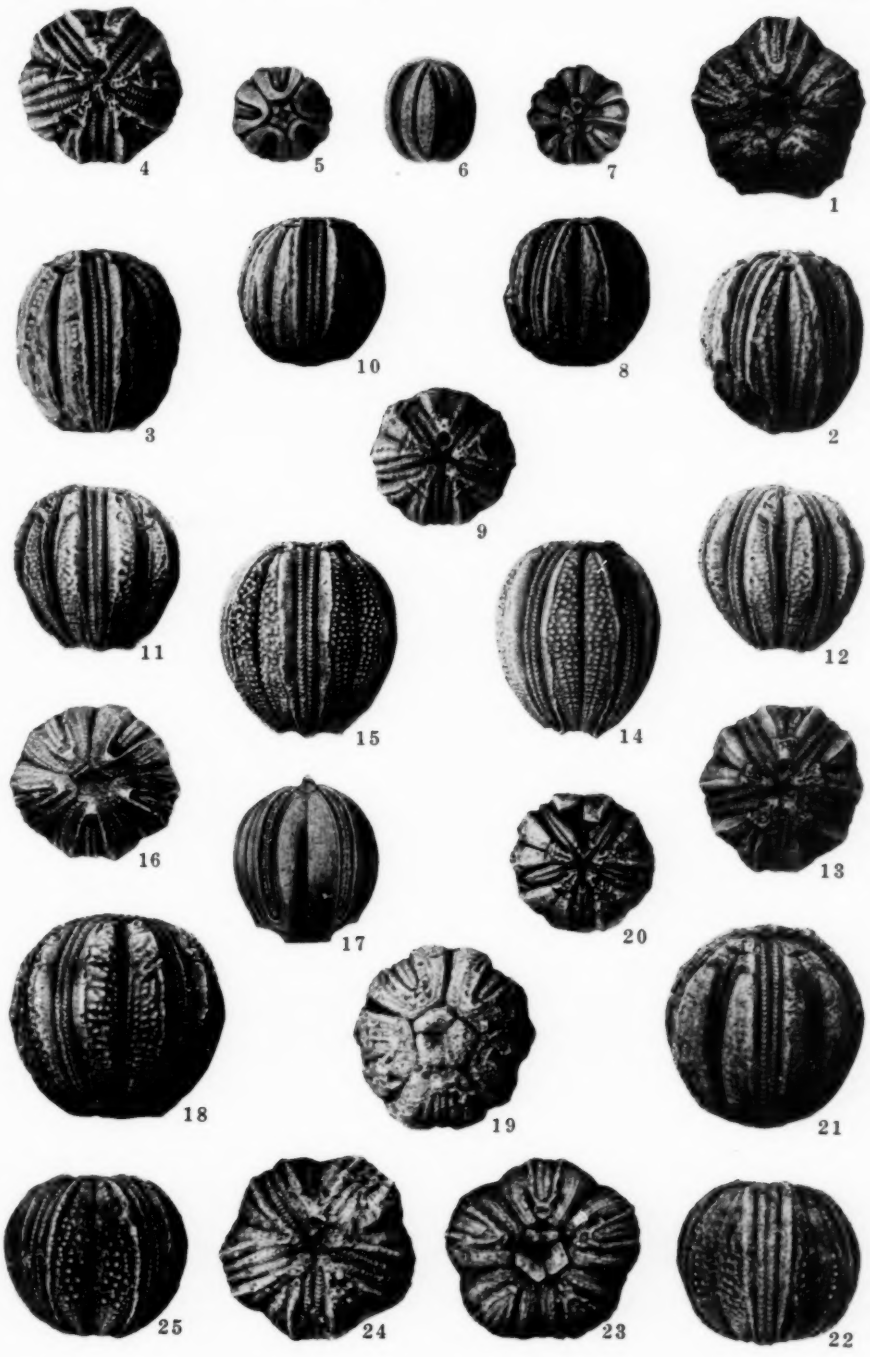
With the exception of figures 5–7 and 17, all of the figures on this plate are unretouched photographs.

FIGS. *1–10—Cryptoblastus melo* (Owen and Shumard) var. *melo* Cline, n. var. *1*, Basal view (×2) of a slightly crushed specimen from the lower Burlington limestone at Hannibal, Mo. *2–4*, Left antero-interambulacral, antero-ambulacral, and summit views (×2) of a specimen from the lower Burlington limestone at Newark, Mo. *5–7*, Basal, interambulacral, and summit views (×1) of the holotype (reproductions of the original illustrations given by Owen and Shumard). *8–10*, Right antero-interambulacral, summit, and left postero-ambulacral views (×2) of a specimen from the lower Burlington limestone at Hannibal, Mo. (p. 637)

11–16—Cryptoblastus melo (Owen and Shumard) var. *calcaratus* Cline, n. var. *11, 12*, Left postero-ambulacral and postero-interambulacral views (×2) of an aberrent specimen from the lower Burlington limestone at Burlington, Iowa. *13–16*, Summit, right postero-interambulacral, right antero-ambulacral, and basal views (×2) of the holotype from the same horizon and locality as the above listed specimen. (p. 640)

17–21—Cryptoblastus melo (Owen and Shumard) var. *projectus* (Meek and Worthen). *17*, Interambulacral view (×2) of the holotype (reproduction of the original illustration given by Meek and Worthen). *18*, Interambulacral view (×2) of a crushed specimen (the specimen appears too wide in the photograph) from the lower Burlington limestone at Burlington, Iowa. *19*, Basal view (×2) of a specimen from the lower Burlington limestone at Hannibal, Mo. *20*, Summit view (×2) of a small specimen from the same horizon and locality as the specimen listed above. *21*, Right antero-ambulacral view (×2) of another specimen from the same horizon and locality as the two preceding specimens. (p. 641)

22–25—Cryptoblastus melo (Owen and Shumard) var. *stellatus* Cline, n. var. Ambulacral, basal, summit, and interambulacral views (×2) of the holotype from the upper Burlington limestone at Hannibal, Mo. (p. 642)



Cline, Mississippian Blastoids

UNIV. OF MICH.

corresponds roughly to that on the posterior plate but a discontinuous depression (rather than an elevation) occupies the median portion.

Ambulacra as in *C. melo* var. *cancellatus*. About 50 side-plates to a row.

Remarks.—The closest relative of *C. melo* var. *calcaratus* is *C. melo* var. *cancellatus*, but it is distinguished from that form by its larger size, its relatively greater width (the height-to-width ratio in *calcaratus* is 12.6/10.7; in *cancellatus* it is 10.5/8.4), in having the periphery nearer the equator, and by the less pronounced reticulate pattern on the base of the radials.

One specimen in my collection appears to be an aberrent individual of the variety *calcaratus* (see pl. 87, figs. 11, 12). It differs radically from *calcaratus* in the proportions of the calyx (it is 12.3 mm. high and 11.9 mm. wide) and it is so nearly symmetrical and so nearly perfect in preservation that there is little possibility of the shape being the result of deformation. It agrees with the holotype in other respects, even in the finest details of surface ornamentation, so I am of the opinion that it is a freak specimen of *calcaratus*, though some would regard it as a mutation of *C. melo* var. *calcaratus*.

Occurrence.—This variety is confined to the lower Burlington formation. It is most abundant in Rowley's *Orophocrinus stelliformis* zone. It is characteristic of a slightly higher horizon than *C. melo* var. *cancellatus*. It seems likely that *calcaratus* developed from *cancellatus* and that the latter continued to live along side of *calcaratus* but in fewer numbers than that variety. Most of my specimens came from Hannibal, Mo., but it occurs elsewhere in that state near the top of the lower Burlington (the *Agaricocrinus* zone and also above the *Orophorcrinus stelliformis* zone in the Marblehead Quarry at Louisiana and the White Bear Quarry near Hannibal). In Iowa it has been found in the lower Burlington limestone at the type section.

Types.—Univ. Iowa; holotype, 762; paratypes, 755–761, inclusive.

CRYPTOBLASTUS MELO (Owen and Shumard) var. PROJECTUS (Meek and Worthen)
Plate 87, figures 17–21

Pentremites melo var. *projectus* MEEK and WORTHEN, *1861*, Acad. Nat. Sci. Philadelphia, Proc., p. 142.

Granatocrinus melo var. *projectus* SHUMARD, *1866*, St. Louis Acad. Sci., Trans., vol. 2, p. 375.

Granatocrinus projectus MEEK and WORTHEN, *1868*, Illinois Geol. Survey, vol. 3, pt. 2, p. 496, pl. 18, fig. 7, and possibly fig. 6*a*.

Schizoblastus? projectus ETHERIDGE and CARPENTER, *1886*, Catalogue of the Blastoidea, p. 223 (also as *Cryptoblastus? melo* var. *projectus* on p. 232).

Granatocrinus neglectus KEYES, *1894*, Missouri Geol. Survey, vol. 4, p. 139 (an error depending upon an incorrect reference).

Cryptoblastus? projectus BATHER, *1899*, The species of Blastoidea, p. 9.

Cryptoblastus projectus ROWLEY, *1900*, Am. Geologist, vol. 26, p. 246.

Cribroblastus projectus HAMBACH, *1903*, St. Louis Acad. Sci., Trans., vol. 13, p. 41.

Calyx medium sized, subglobose, a little higher than wide. The figured holotype of Meek and Worthen was 11.5 mm. high and 10 mm. wide. My specimens average 12 mm. high and 11.4 mm. wide, but in each specimen part of the base or summit is missing, so that the average height must have been a little more than 12 mm. Periphery equatorial. Transverse section subdecagonal. Longitudinal section slightly elliptical. Summit almost flat, contracted. Base flat to slightly protuberant, contracted, equal in size to summit.

Stem-base lying in a small concavity in the otherwise protuberant base, outer margin crenulated, in diameter about one-third that of basalia. Base small, but large for this species, forming a slightly convex cup, and visible from side. Each basi-radial suture rests in a prominent groove.

Radials reaching about two-thirds length of calyx measured around the outside, entirely visible from side, prominent in both oral and basal views. The marginal ridge surrounding the sinus, so marked in other varieties of *C. melo*, is not well developed in this variety.

Lower portions of deltoids ornamented

with wart-like elevations; upward, near the height of the spiracles, a longitudinal ridge bounds each lateral border.

Ambulacra extend almost length of calyx, although they are relatively short for a variety of *C. melo;* proximal ends depressed below surface of deltoids and upper ends of radials, but becoming level with radials a little below periphery and maintaining this relative position throughout rest of their length. About 45 side-plates to a row.

Remarks.—When Meek and Worthen described this form they regarded it as a variety of *Cryptoblastus melo*, but later they stated that

> subsequent examinations of a large number of specimens of that species, in various conditions, have led us to the conclusion that it is a distinct species.

Rowley (1900, p. 246) said that

> *Cryptoblastus projectus* is probably nothing more than a strongly marked variety of *melo*, although the ornamentation is much finer.

I have five specimens which are conspecific with the holotype figured by Meek and Worthen. If I had seen only these five specimens, I would be inclined to agree with Meek and Worthen that *C. projectus* is of specific rank, but I also have a larger number of specimens which show much variation in the convexity and prominence of the base—in some it is convex and protuberant—in some it is flat but still distinctly visible in a lateral view—yet in others it is just barely visible from the side. Some forms seem to be intermediate between the type of *C. projectus* and *C. melo* var. *melo*. Accordingly, I am inclined to agree with Rowley that *C. projectus* is a variety of *C. melo*.

C. melo var. *projectus* is distinguished from other varieties of this species by its more protuberant base and correspondingly less prominent radial lips.

Occurrence.—Lower Burlington at Hannibal, Mo., and Burlington, Iowa. Keyes and Rowley (1897, p. 32) record it from the lower Burlington at Louisiana, Mo. It seems to be characteristic of a zone near the middle of the lower Burlington limestone.

Types.—Location of holotype unknown; possibly it is in the Illinois State Museum at Springfield. Hypotypes, Univ. Iowa, 747–754.

CRYPTOBLASTUS MELO (Owen and Shumard) var. STELLATUS Cline, n. var.
Plate 87, figures 22–25

Calyx medium sized, depressed, globose, wider than high. The single known representative is 11.5 mm. high and 13.5 mm. wide. Transverse section roughly pentagonal. Longitudinal section depressed elliptical. Periphery equatorial. Summit flat. Base wider than in most

---

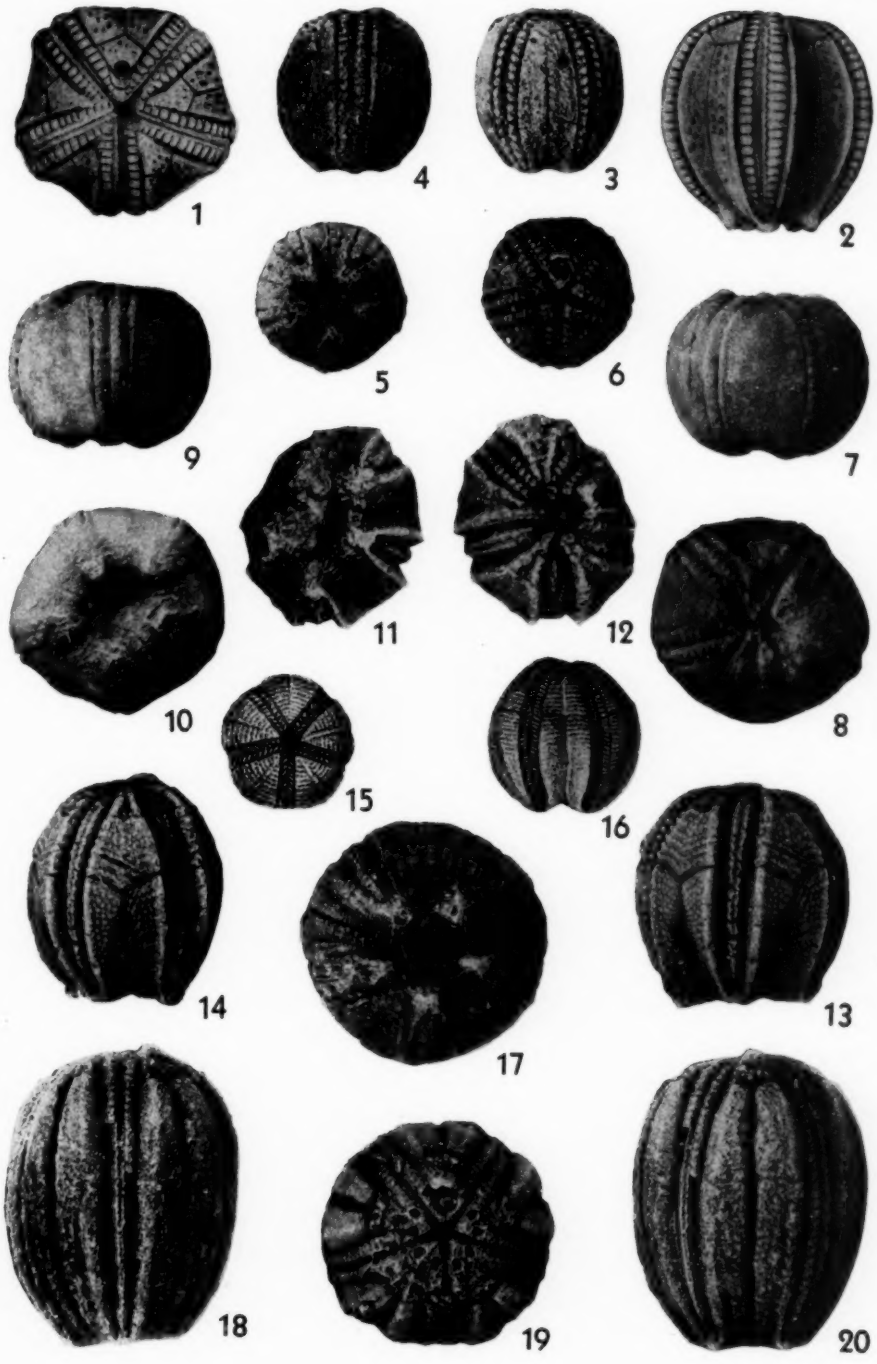
EXPLANATION OF PLATE 88

FIGS. *1–6—Cryptoblastus pisum* (Meek and Worthen). *1, 2*, Summit and ambulacral views (×4) of the figured type (reproductions of the original illustrations given by Meek and Worthen). *3–6*, Right antero-interambulacral, right postero-ambulacral, basal, and summit views (×4) of a specimen from the upper Burlington limestone at Burlington, Iowa. (p. 645)

7–10—Cryptoblastus rowleyi Cline, n. sp. Left postero-interambulacral, summit, left postero-ambulacral, and basal views (×4) of the holotype from the lower Burlington limestone at Louisiana, Mo. (p. 648)

11–16—Cryptoblastus granulosus (Meek and Worthen). *11–14*, Basal, summit, antero-ambulacral, and right antero-interambulacral views (×4) of a laterally crushed specimen from the upper Burlington limestone at Springfield, Mo. *15, 16*, Summit and interambulacral views (×2) of the figured type (reproductions of the original illustrations given by Meek and Worthen). (p. 643)

17–20—Cryptoblastus melo (Owen and Shumard) var. *cancellatus* Cline, n. var. Basal, right postero-ambulacral, summit, and postero-interambulacral views (×4) of the holotype from the lower Burlington limestone at Burlington, Iowa. (p. 639)



Cline, Mississippian Blastoids

UNIV. OF MICH.

varieties of the species and almost flat.

Basalia projects slightly below lower ends of ambulacra and is just visible in lateral view. Basi-radial suture prominent.

Adoral ends of ambulacra are depressed a little below sinus border, but below periphery they become level with radials, and the aboral ends are elevated a little above radials.

Remarks.—This is the only variety of *C. melo* which is known to occur above the lower division of the Burlington; it is found in the *Dorycrinus* zonule of the uppermost part of the Burlington. Its flat base, barely visible in a lateral view, stamps it as a near relative of *C. melo* var. *projectus*, and since it occurs stratigraphically above *projectus* it likely evolved from that form. It differs noticeably from *C. projectus* in being more nearly pentagonal in transverse section, in having more prominent radial ridges bordering the sinus, in less prominent interradial grooves, and in being wider than high. From *C. melo* var. *melo* it is readily distinguished by its flat base and a different height-to-width ratio.

Occurrence.—Near the top of the upper Burlington limestone at Hannibal, Mo. Collected by L. R. Laudon.

Holotype.—Univ. Iowa, 746.

CRYPTOBLASTUS? SHUMARDI
(Meek and Worthen)

Granatocrinus shumardi MEEK and WORTHEN, *1866*, Acad. Nat. Sci. Philadelphia, Proc., p. 257; *1868*, Illinois Geol. Survey, vol. 3, pt. 2, pp. 498, 499, pl. 18, fig. 6*b* (not 6*a*).
Schizoblastus? shumardi ETHERIDGE and CARPENTER, *1886*, Catalogue of the Blastoidea, p. 223.—BATHER, *1899*, The species of Blastoidea, p. 65; *1908*, Neues Jahrb., Beilage-Band 25, p. 317.
Mesoblastus? shumardi ETHERIDGE and CARPENTER, *1886*, Catalogue of the Blastoidea, pp. 244, 245.

I have one badly crushed specimen which appears to represent *Granatocrinus shumardi* Meek and Worthen (1868). The specimen was collected by Frank Springer at Burlington, Iowa, and was labeled (apparently by Springer) *Cryptoblastus shumardi* (Meek and Worthen). The specimen is so poorly preserved that little can be added to the original description given by Meek and Worthen, although they knew nothing of the internal structure of the holotype. I cannot tell from my specimen whether or not an hydrospire-plate is present, but partly because of the extremely short deltoid plates I am tentatively placing it in the genus *Cryptoblastus*.

Occurrence.—The holotype was in the Wachsmuth collection and Meek and Worthen stated that it came from the "Burlington group" at Burlington, Iowa. The specimen I am studying came from the same place from the lower part of the formation.

Described specimen.—Univ. Iowa, 3,259.

CRYPTOBLASTUS GRANULOSUS
(Meek and Worthen)
Plate 88, figures 11–16

Pentremites (*Granatocrinus?*) *granulosus* MEEK and WORTHEN, *1865*, Acad. Nat. Sci. Philadelphia, Proc., p. 165.
Granatocrinus granulosus SHUMARD, *1866*, St. Louis Acad. Sci., Trans., vol. 2, p. 375.—MEEK and WORTHEN, *1873*, Illinois Geol. Survey, vol. 5, pt. 2, pp. 508, 509, pl. 15, figs. 10*a*, *b*.—KEYES and ROWLEY, *1897*, (?) Iowa Acad. Sci., Proc., vol. 4, p. 32.
Schizoblastus? granulosus ETHERIDGE and CARPENTER, *1882*, Annals and Mag. Nat. Hist., 5th ser., vol. 9, p. 247; *1886*, Catalogue of the Blastoidea, p. 223.—BATHER, *1899*, The species of Blastoidea, p. 63.
Pentremites granulosus HAMBACH, *1884*, St. Louis Acad. Sci., Trans., vol. 4, no. 4, pl. D, figs. 4, 4*a* (according to Hambach these are figures of the holotype).
Cribroblastus granulosus HAMBACH, *1903*, St. Louis Acad. Sci., Trans., vol. 13, p. 40 (it is not possible to tell if fig. 12 on pl. 5 represents this species).
Schizoblastus granulosus BATHER, *1908*, Neues Jahrb., Beilage-Band 25, p. 316.—CLARK, *1917*, Harvard Coll., Mus. Comp. Zoology, Bull., vol. 61, no. 9, p. 373.

Calyx small, rarely attaining medium size. Subglobular in shape, height and width about equal; measurements of holotype (Meek and Worthen, 1873) are: height, 0.22 inch; width, 0.23 inch. Four specimens in my collection average 8.3 mm. high and 8.1 mm. wide; the largest specimen is 12.3 mm. high and the

smallest 6.8 mm. high. Periphery equatorial. Summit contracted. Base truncated, concave; lower ends of ambulacra protruding slightly below base and slightly expanded laterally. Transverse section at height of radio-deltoid suture almost circular, but at equator is faintly pentagonal and just above radial lips is distinctly pentagonal.

Stem-base resting in a concavity and hidden in a lateral view. Basalia not well preserved in my specimens, but is exceedingly small and entirely hidden within the basal cavity.

Radials large, reaching almost two-thirds length of calyx measured around the outside. Bodies short, turned under and comprising largest part of basal concavity, invisible from side. Lips prominent, forming a quinquepod on which the calyx rests; inner portion of each forming a small hook-like projection which curves slightly inward over lower end of ambulacrum. Limbs long, sides almost straight, deeply truncated at radio-deltoid suture; inner margin raised into a low, indistinct ridge which curves around lower portion of sinus and connects with ridge on opposite side. Interradial sutures inconspicuous and easily obscured by weathering. Radial ornamentation consists of parallel rows of closely spaced granules which curve around the sinus and extend upward along each limb, slightly deflected away from the interradial suture, occasionally cutting in abruptly to end at the radial sinus and giving a festoon-like pattern to some specimens. In addition, the lower portions of limbs bear transverse rows of granules which give a faint reticulate pattern to lower portion of calyx; this ornamentation shows only on the best-preserved specimens.

Deltoids extending one-third length of calyx, which is unusually long for *Cryptoblastus*, prominent in lateral view, comprising most of field in oral view; width almost one-half length of plate; constricted just below apex by spiracles but expanded above to give the outline of a spear-head. Posterior deltoid most prominent because of the elevated distal border of anus. Lower portions of deltoids marked by rows of granules parallel to the faintly trilobate radio-deltoid sutures. Meek and Worthen (1873, p. 508) state that the granules on the holotype are more strongly defined on the deltoids than on the radials, but in my specimens this depends largely on the state of preservation of the calyx; in some specimens radial ornamentation is more pronounced than that of the deltoids.

Ambulacra narrow, widest midway between the spiracles and radio-deltoid suture, narrowing moderately above and gradually below, and slightly depressed below sinus border throughout its length. Lancet slightly wider than thick, perforated by a small subcentral canal; adoral portion exposed; greatest width attained where ambulacra are widest, at which point the lancet comprises less than one-third the width. Aborally the lancet becomes completely overlapped by side-plates. In the holotype there are from "twenty-five to thirty" side-plates to a row; in my largest specimen there are forty-two and in the smallest there are twenty-five. Outer side-plates not well known, but small, wedge-shaped, wider than high (width almost that of side-plates), and the sutures resulting from their junction with the side-plates converge upward on the center of the ambulacrum. The hydrospire-plates share the ambulacral pores jointly with the edges of the radials and are visible upon removal of the outer side-plates. One badly crushed specimen shows grooves along the inside edges of the deltoids; these grooves, unlike those in the hydrospire-plate, are not visible from the exterior when the side-plates are removed and they seem to be the adoral continuation of the hydrospire pores, although no hydrospire-plate is present along the edges of the deltoids to form the inner walls of the pores. Ambulacral pores, although inconspicuous, are present above the radio-deltoid suture and are bordered on the inside by

the lancet. Hydrospire folds as in other described species of *Cryptoblastus*.

Spiracles excavated in lateral margins of deltoids near apices, the notches being closed on the outside by lancet and sideplates. Anus piercing center of posterior deltoid near apex; aboral border raised into a process which partially closes it.

Remarks.—Etheridge and Carpenter (1882, p. 247) referred this species with question to *Schizoblastus*, although they gave no reason for so doing. Bather apparently followed them in 1899 (p. 63) when he referred it with question to *Schizoblastus*, but he later definitely referred it to *Schizoblastus* (1908, p. 318). I was at first inclined to place *granulosus* in *Schizoblastus* because of the ambulacral pores (but not hydrospire pores) above the radio-deltoid sutures. It was the absence of pores (connecting the hydrospire folds with the outside) above the suture which suggested the name *Cryptoblastus* to Etheridge and Carpenter for such blastoids as *C. melo*. I am now inclined to place *granulosus* in *Cryptoblastus* notwithstanding the presence of ambulacral pores above the radio-deltoid sutures, because it agrees more closely with the genotype of *Cryptoblastus* than the genotype of *Schizoblastus*. The presence of an hydrospire-plate, the facts that the posterior pair of spiracles are fused with the anus, that the radials overlap the deltoids, and that the radials are longer than the deltoids all suggest a relationship with *Cryptoblastus* rather than with *Schizoblastus*. *C. granulosus* is characterized by its relatively long deltoids and its granular ornamentation. It may be distinguished from *C? roemeri* by its longer deltoids. It is somewhat similar to *C? calycinus* (Rowley), also of the upper Burlington limestone. Rowley (1900) states that the radials of *calycinus* are "scarcely more than half the length of the body" but his illustrations show them to be more than two-thirds the body length; according to him it is the smallest blastoid from the Burlington, although I have specimens of *C. granulosus* which are about the size of Rowley's figured specimens. It is not possible to tell from Rowley's brief description or his diagrammatic drawings if *calycinus* is a small form of *C. granulosus*, and until Rowley's types have been made available for study it seems best to regard the two as different species.

Occurrence.—The specimen figured by Meek and Worthen (the holotype) came from the "Keokuk division" of the Osage group near Warsaw, Ill. Keyes and Rowley (1897, p. 32) reported it from the upper Burlington limestone at Louisiana, Mo. Hambach (1903, p. 40) also lists its position as the upper Burlington. All of the specimens in my collection came from the upper Burlington; Frank Springer collected four from Burlington, Iowa, and Laudon and I collected six from the upper Burlington at Springfield, Mo.

Types.—Location of holotype unknown; it was probably deposited in the Illinois State Museum. Hypotypes, Univ. Iowa, 743–745, and 3,266.

CRYPTOBLASTUS PISUM
(Meek and Worthen)
Plate 88, figures 1–6

Granatocrinus pisum MEEK and WORTHEN, *1869*, Acad. Nat. Sci. Philadelphia, Proc., p. 89; *1873*, Illinois Geol. Survey, vol. 5, pp. 470, 471, pl. 9, figs. 4*a*, *b*.—KEYES and ROWLEY (?), *1897*, Iowa Acad. Sci., Trans., vol. 4, p. 32.

Cryptoblastus pisum ETHERIDGE and CARPENTER, *1886*, Catalogue of the Blastoidea, p. 232.—BATHER, *1899*, The species of Blastoidea, p. 9.

Granatocrinus exiguus ROWLEY and HARE, *1891* (part?), Kansas City Scientist, vol. 5, no. 7, p. 100, pl. 2, figs. 13, 14; vol. 5, no. 8, pl. 3, fig. 18.

Granatocrinus? pisum ROWLEY, *1900*, (?) Am. Geologist, vol. 26, pp. 248, 251.

Cribroblastus pisum HAMBACH, *1903*, St. Louis Acad. Sci., Trans., vol. 13, p. 41 (but not fig. 13 on pl. 5).

The original description of this species was drawn up by Meek and Worthen from a single specimen and the nature of the internal structure was not known. The following revised description is based on their description and on eleven specimens in my collection.

Calyx small, subovate, slightly higher than wide. The figured holotype (Meek and Worthen, 1873, pl. 9, figs. 4*a*, *b*) is 7 mm. high and 6.7 mm. wide. My specimens are smaller than the holotype but they agree with it in all other respects; four mature specimens average 6 mm. high and 5.4 mm. wide. A transverse section above the equator is almost circular; the equatorial section is subcircular to faintly pentagonal; below the equator the section becomes increasingly pentagonal because of the gradual elevation of the ambulacral areas. Longitudinal section subovate, largest above, lower end slightly truncate. Periphery just above equator. Summit faintly convex with a concave central portion. Base distinctly concave, pentagonal in outline; lower ends of ambulacra protrude slightly to form a quinquepod.

Stem-base a little less than one-third maximum diameter of basalia; periphery crenulated. Basals small; maximum diameter about one-half that of pentagon enclosed by lower ends of ambulacra. Azygous basal quadrate (in one small individual it is faintly hexagonal); paired basals larger and pentagonal. Basi-radial sutures inconspicuous.

Radials reaching almost three-fourths length of calyx, prominent in basal view, less prominent in oral view. Bodies short, incurved, invisible in lateral view. Limbs long and narrow, widest at periphery, gradually tapering above and below; in longitudinal section gently convex; in transverse section almost flat in upper portion but becoming slightly concave below. Inner edges of limbs elevated into low, faint ridges completely surrounding radial sinuses. Interradial sutures inconspicuous. Radial lips form small hook-like processes which are incurved over lower ends of ambulacra. Radial ornamentation consists of minute lirae curving around lower end of plate and they extend upward along each limb becoming coarser and finally nodose; these rows are directly slightly toward the radial sinus below periphery but above are deflected back toward interradial sutures at about the same angle, producing a sublanceolate design in each interambulacral area.

Deltoids subtriangular, about twice as long as wide; visible in side view; lower ends very convex, the net result being a rather large summit. Constricted near apex by spiracles producing an arrow- or beard-shaped apex; borders of apex crenulate. Transverse rows of nodes roughly parallel to radio-deltoid suture adorn lower portion of deltoid. Portion above spiracles more elevated than rest of plate. Posterior deltoid most conspicuous.

Ambulacra widest at a position about one-third the length of a deltoid above the radio-deltoid suture, their combined widths comprising more than one-half of circumference of calyx; at the equator their widths total about one-fifth the circumference. Ambulacra slightly elevated above sinuses throughout their lengths.

Lancet quadrate in cross-section, thicker than wide, exposed adorally; exposed portion comprising about two-sevenths width of ambulacrum, becoming hidden by overlapping side-plates near lower end. Side-plates resting principally on lateral sides of lancet, but partly supported by hydrospire-plate which becomes visible upon weathering. Twenty-six side-plates on each side of lancet in holotype; maximum number observed in my specimens was 21; this apparent discrepancy is explained by the smaller size of my specimens. There are ten specimens in my collection and seven of them have about 21 plates on each side of lancet; the smallest specimen has only 13. It is a curious fact that the side-plates in the smallest specimen (3.5 mm. high) are almost as large as those in the largest specimens. Meek and Worthen (1873, pp. 470, 471) have previously mentioned that the side-plates in this species are proportionately large.

Four long, narrow hydrospire folds beneath each ambulacrum, each swelling inward into a longitudinal tube which appears sac- or bulb-like in transverse section.

Eight small oval spiracles excavated so deeply within lateral edges of deltoids as to be almost enclosed by them, but each is bordered aborally by a side-plate.

Remarks.—*Granatocrinus pisum* was one of the four species referred to *Cryptoblastus* when Etheridge and Carpenter (1882, p. 232) founded that genus. Their determination was based on the absence of ambulacral pores above the radio-deltoid suture. Rowley (1900, p. 248) evidently was uncertain as to the generic affinities of *G. pisum*. After studying eleven specimens, I am convinced that *G. pisus* is congeneric with the genotype of *Cryptoblastus*. The presence of an hydrospire-plate extending the length of the sinus, the small oval spiracles excavated in each lateral edge of the deltoids, the aborally sloping radio-deltoid surface, and the lack of ambulacral pores above the radio-deltoid suture show definitely that it belongs to *Cryptoblastus*.

One of the specimens which I am studying was in the Springer collection at Iowa University, and it was one of two specimens which Springer had obtained from Rowley and which Rowley had identified as *Granatocrinus exiguus* Rowley and Hare. If the figures which Rowley and Hare (1900a, pl. 2, figs. 13, 14; 1900b, pl. 3, fig. 18) have published are correct (and it must be assumed that they are, at least until the types have been made available for study), neither of the two specimens which he traded Springer are conspecific with *G. exiguus* —they differ too much in gross form. Furthermore, the two specimens do not seem to be conspecific; one of them I am tentatively referring to *Cryptoblastus pisum* and the other one I am describing as a new species.

Cryptoblastus pisum is characterized by its small size, by a relatively large and gently convex summit, and a distinctly concave base. The deltoids, which reach almost one-fourth the length of the calyx, are relatively long for the genus. The spiracles are almost surrounded by the deltoids and the gap is closed by a side-plate, rather than the lancet as is the case in most species of the genus. The interradial sutures are less distinct than in other species of *Cryptoblastus*. The elevated ambulacra, which are widest above the radio-deltoid suture, are an additional characteristic.

The species is distinguished from *C. melo* var. *melo* by its smaller size, larger deltoids, less numerous and proportionately larger side-plates, inconspicuous interradial sutures (in contrast to the deep grooves in *melo*), its elevated, rather than depressed, ambulacra, and a more nearly circular equatorial section.

Rowley stated in 1900 (p. 248) that

> *Granatocrinus exiguus* is probably nothing more than a strongly marked variety of *G. pisum*.

A close comparison with the description and figures of *Granatocrinus exiguus* Rowley and Hare shows that *G. exiguus* is distinctly more globular, and the radial lips are more strongly directed outward than in *Cryptoblastus pisum*. The authors state that the spiracles had not been observed in *G. exiguus*, but it is evident from the rest of their description that *Granatocrinus exiguus* should be referred to *Cryptoblastus*, and the figures show that it is closely allied to, though distinct from, *C. pisum*.

Occurrence.—The holotype, no. 397 of the Wachsmuth collection, came from the upper Burlington limestone at Burlington, Iowa. Keyes and Rowley (1897, p. 32) have listed it as occurring in the third and fourth divisions of the lower part of the Burlington limestone at Louisiana, Mo., and Rowley (1900, p. 248) has since stated that

> *Granatocrinus? pisum* accompanies *C. melo* throughout its range but is never abundant;

this statement would be interpreted as meaning that it ranged throughout the lower Burlington.

Four of my specimens were collected by Frank Springer from the upper Burlington limestone at Burlington (thus, they are topotypes), one was collected by Rowley from the lower Burlington white

chert at Louisiana, Mo., and the remaining six were collected by Springer from the Lake Valley beds at Lake Valley, N. Mex.

Types.—Whereabouts of holotype unknown. Topotypes, Univ. Iowa, 3,264. The remaining specimens on which the above description is based are Univ. Iowa, nos. 742, 3,281, and 3,624.

CRYPTOBLASTUS ROWLEYI Cline, n. sp.
Plate 88, figures 7–10

Granatocrinus exiguus ROWLEY and HARE, *1891* (part?), Kansas City Scientist, vol. 5, no. 7, p. 100, pl. 2, figs. 13, 14; no. 8, pl. 3, fig. 18.—ROWLEY, *1900* (part?), Am. Geologist, vol. 26, p. 248.

Calyx small, depressed globose, distinctly wider than high; the holotype is 5.7 mm. high and 7.5 mm. wide. Periphery equatorial. Transverse section a little above equator is subcircular, a little below periphery it is slightly pentagonal, and just above radial lips is strongly pentagonal. Summit large, slightly concave. Base about size of summit, appearing truncated in lateral view, decidedly concave; lower ends of ambulacra protrude so as to form a quinquepod which supports the upright calyx.

Basals small; maximum diameter considerably more than one-half that of pentagon enclosed by lower ends of ambulacra; forming a concave cup which is hidden in lateral view. Basiradial sutures discernible in the holotype but not prominent.

Radials long, reaching about three-fourths length of calyx, extending almost height of calyx in lateral view, prominent in basal view, and easily visible orally. Bodies short; incurved, taking part in basal concavity; not visible from side. Limbs long, widest near equator, narrowing very gradually above and below; upper ends deeply truncated by radio-deltoid suture. Each limb gently convex longitudinally; transverse section gently convex except for lower portion which becomes slightly concave. Inner edge of limb raised into a low longitudinal ridge; outer edge meets adjacent radial in an inconspicuous interradial suture. Holotype so poorly preserved that details of surface ornamentation are not discernible.

Deltoids reaching almost one-fourth length of calyx; lower ends visible in lateral view; about twice as long as wide. Roughly triangular in outline; from the base upward the triangle narrows at a uniform rate to a position about one-half height of plate, where the rate decreases; apex has outline of a spear-head. Near apex lateral borders are raised into longitudinal ridges but these ridges die out downward. Posterior deltoid more conspicuous than others because of an elevated hood-like process which borders the anus aborally. Radio-deltoid suture inconspicuous; obtusely V-shaped, the downward directed apex making an angle of about 135 degrees.

Ambulacra widest a little above radio-deltoid suture, narrowing rapidly above and very gradually below; at the equator they comprise a little more than one-fourth circumference of calyx, but where they are widest they comprise at least one-half the circumference. Ambulacra slightly raised above sinus borders throughout their lengths. Adorally the lancet is exposed but aboral end is completely hidden by side-plates. Ambulacral groove prominent. About 25 side-plates on each side of lancet. They are not well preserved but they appear to be similar to those in *C. pisum*.

Spiracles excavated chiefly in lateral edges of deltoids but openings partially closed by ambulacra. Anus rather large.

Remarks.—The holotype of this species was collected by Professor Rowley and was identified by him as *Granatocrinus* [*Cryptoblastus?*] *exiguus* Rowley and Hare. However, the specimen differs widely in shape from their figured types. It is possible that the specimen is only a variety of *C. exiguus* [which Rowley (1900, p. 248) finally believed to be only a strongly marked variety of *C. pisum* (Meek and Worthen)], but until Rowley's types have been made available, it seems best to regard it as a distinct species and I propose to call it *Crypto-*

blastus rowleyi in honor of its collector, the late Professor Rowley.

Cryptoblastus rowleyi can be distinguished from both *C. pisum* and *C. exiguus*, its closest relatives, by its relatively much wider calyx.

Occurrence.—Lower Burlington formation, Louisiana, Mo.

Types.—Holotype, Univ. Iowa, 741.

REFERENCES

BATHER, F. A., *1899, List of the genera and species of Blastoidea in the British Museum* (London).

———, *1908*, in Boehm, G., Geologische Mitteilungen aus dem Indo-Australischen Archipel.: *Neues Jahrb.*, Beilage-Band 25, pp. 303–319.

CLINE, L. M., *1936*, Blastoids of the Osage group, Mississippian; Part I, The genus *Schizoblastus: Jour. Paleontology*, vol. 10, no. 4, pp. 260–281, pls. 44, 45.

ETHERIDGE, ROBT., JR., and CARPENTER, P. H., *1882*, On certain points in the morphology of the Blastoidea, with descriptions of some new genera and species: *Annals and Mag. Nat. Hist.*, 5th ser., vol. 9, pp. 213–252.

———, *1886, Catalogue of the Blastoidea* (London).

HAMBACH, G., *1903*, Revision of the Blastoidea, with a proposed new classification, and description of new species: *St. Louis Acad. Sci., Trans.*, vol. 13, pp. 1–67, pls. 1–6.

KEYES, CHARLES R., and ROWLEY, R. R., *1897*, Vertical range of fossils at Louisiana (Missouri): *Iowa Acad. Sci., Proc.*, vol. 4, pp. 26–40.

MEEK, F. B., and WORTHEN, A. H., *1861, Acad. Nat. Sci. Philadelphia, Proc.*, pp. 128–148.

———, *1868, Illinois Geol. Survey*, vol. 3, pt. 2, pp. 450–565, pls. 14–20.

———, *1873, Illinois Geol. Survey*, vol. 5, pp. 323–619, pls. 1–32.

MOORE, RAYMOND C., *1928*, Early Mississippian formations in Missouri: *Missouri Bur. Geol. and Mines*, 2d ser., vol. 21.

OWEN, D. D., and SHUMARD, B. F., *1850, Acad. Nat. Sci. Philadelphia, Jour.*, vol. 2, pp. 57–70, pl. 7.

———, *1852*, Descriptions of one new genus and twenty-two new species of Crinoidea: in Owen, D. D., *Report of a geological survey of Wisconsin, Iowa, and Minnesota*, pp. 587–599, pls. 5*a*, 5*b*.

PECK, R. E., *1929*, Blastoids from the Chouteau limestone (abstract): *Geol. Soc. America, Bull.*, vol. 40.

ROWLEY, R. R., *1900a*, New species of crinoids, blastoids, and cystoids from Missouri: *Am. Geologist*, vol. 25.

———, *1900b*, Notes on the fauna of the Burlington limestone at Louisiana, Missouri: *Am. Geologist*, vol. 26, pp. 245–251.

ROWLEY, R. R., and HARE, S. J., *1891a*, Description of some new species of Echinodermata from the Sub-Carboniferous rocks of Pike County, Missouri: *Kansas City Scientist*, vol. 5, no. 7, pp. 97–103, pl. 2.

———, *1891b*, Description of some new species of crinoids and blastoids from the Sub-Carboniferous rocks of Pike and Marion counties, Missouri, and Scott County, Virginia: *Kansas City Scientist*, vol. 5, no. 8, pp. 113–118, pl. 3.

WACHSMUTH, CHARLES, *1886*, On a new genus and species of blastoids: *Davenport Acad. Nat. Sci., Proc.*, vol. 4.

L. M. CLINE, IOWA STATE COLLEGE, AMES, IOWA. MANUSCRIPT RECEIVED BY THE EDITOR, JANUARY 15, 1937.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 8, PP. 650–660, PL. 89, DECEMBER, 1937

STRATIGRAPHY AND FAUNA OF THE SACAJAWEA FORMATION, MISSISSIPPIAN, OF WYOMING

C. C. BRANSON

ABSTRACT

The lower part of the Amsden is Mississippian in age and is here described and named the Sacajawea formation to separate it from the upper part of the Amsden (Pennsylvanian). Thirty-one species are added to the known fauna, of which eleven are new. The new species belong to the genera *Clionolithes, Spirorbis, Rhipidomella, Chonetes, Linoproductus, Streptorhynchus, Selenella?, Composita, Euphemites, Conocardium,* and *Griffithides.*

The Sacajawea formation is separated in this paper from the lower part of the Amsden formation of Darton (1906), named from a type locality in the northeastern part of the Bighorn Mountains of Wyoming. Darton described the formation as a series with red shale at the base, overlain by beds of sandstone and limestone with much colored chert. The limits of the Amsden were established at the top of the Madison limestone, beneath, and at the base of the massive cross-bedded Tensleep sandstones, above. A Mississippian coral, *Menophyllum excavatum*, was found in the lower part, but a Pennsylvanian faunule was collected from the upper cherty beds on North Fork of Crazy Woman Creek, and Darton recognized that the formation includes beds of both periods.

Branson and Greger (1918) have described a considerable fauna of Ste. Genevieve age from the lower part of the Amsden in the Wind River Mountains. P. S. Morey (1935) has recently described an ostracode fauna from the same locality and he concurs in the age determination. The present paper describes additional species which have been collected by University of Missouri field parties and by me since the publication of Branson and Greger's work. All of the fossils mentioned above were collected from the lower part of the Amsden on Twin Creek, Cherry Creek, and Little Popo Agie River, in the south end of the Wind River Mountains, and from Bull Lake Creek, in the northern end of the same range. With exceptions of the coral mentioned by Darton and of an inconclusive faunule from the "lower or mollusk zone" of the Amsden in the Gros Ventre Mountains, these comprise all the Mississippian fossils known from beds that have been called Amsden.

Pennsylvanian fossils have been reported from the Amsden in a number of widely scattered localities, notably from Rawlins (Lee, 1927), from the Gros Ventre Mountains (Blackwelder, 1913), and from Greybull (Brainerd and Keyte, 1927), in addition to those from the North Fork of Crazy Woman Creek in the Bighorn Mountains, all from higher beds in

the formation. It is evident that the Amsden, as defined, includes strata representing two periods. The stratigraphic relationships of the formation are difficult to make out, for talus from the overlying Tensleep sandstone covers it in most places, and the lower part of the Amsden is seldom exposed. I have been able to find but one exposure in which all the beds of the Amsden are exposed and in which both Mississippian and Pennsylvanian fossils are found. On Bull Lake Creek, about 2 miles above Bull Lake, a complete section can be measured in the south wall of the canyon and in the hogbacks in the center of the valley. The Madison limestone is overlain unconformably by red and yellow sandstone and shale and heterogeneous breccia. These beds weather to form arches and caverns above the contact. In the south wall of the canyon near a large spring is a former cave into which large blocks of Madison have slumped so that there is the appearance of angular unconformity, and the cave was later filled by muds which are now gray and greenish shales. This particular cave involves Madison and lower Amsden beds and may have developed along the contact after deposition of the Mississippian part of the Amsden. Above the sandstone, shales, and breccia is 43 feet of limestone, bearing in its lower part a Ste. Genevieve fauna. Above this limestone lies 21 feet of nonfossiliferous laminated limestone in irregular contact with the bed below, but it is not certain whether the contact is unconformable or merely a solution contact. The upper Amsden consists of 80 feet of sandstone overlain by 96 feet of limestone, sandstone, and shale. The sandstone rests with pronounced unconformity upon the laminated limestone. Portions of the upper bed of limestone are cut out and blocks of limestone are incorporated in the lower part of the sandstone.

Section of Carboniferous on Bull Lake Creek, Wyoming

	Fee
Phosphoria formation (Permian)	
Tensleep sandstone (massive cross-bedded sandstone, calcareous sandstone, and thin limestone).....	357
Upper Amsden formation	
1. Light-gray cherty limestone and chert with Pennsylvanian fossils.	5
2. Light-buff sandstone, cherty, with thin limestone.....	8
3. Light-gray cherty limestone with Pennsylvanian fossils.....	3
4. Limestone and sandstone in thin beds.....	25
5. Compact gray limestone with green shale partings.....	3
6. Light-gray limestone and green shale.....	42
7. Compact light-gray cherty limestone.....	10
8. Light-gray sandstone.....	14
9. Light-buff to reddish sandstone, disconformable on bed below.....	66
Lower Amsden formation (possibly of Chester age)	
10. Compact gray limestone.....	2
11. Light brownish-gray crystalline limestone.....	3
12. Laminated light-gray cherty limestone.....	7
13. Light-buff laminated limestone, disconformable on bed below (?)...	9
Sacajawea formation	
14. Massive crystalline light-gray cherty limestone, with Ste. Genevieve fauna in lower 20 feet.	43
15. Red and buff sandstone and shaly sandstone, breccia in places, shale cave filling in places, disconformable on beds below.....	2–11
Madison limestone (lower Mississippian)	

The beds numbered 14 and 15 in

the accompanying section, consisting of the basal beds of sandstone, shale and associated breccia and of the 43 feet of limestone in which the fossils occur, are here designated the Sacajawea formation. The name is taken from Mount Sacajawea at the head of Bull Lake Creek in the Wind River Mountains. A store and inn of that name are on the Yellowstone Park highway near the mouth of Bull Lake Creek. The word is the Shoshone name of Bird Woman, guide of the Lewis and Clark expedition. The exposure on Bull Lake Creek is necessarily the type section, as it is the only measurable section containing fossils. It is not strictly representative lithologically, for in the southern part of the range there is a series of hematitic red shale beds near the base, and in some sections there is a basal sandstone. Dr. E. M. Parks of Tensleep, Wyo., tells me that well logs there show 110 feet of sandstone overlain by 80 feet of red shale. Near Stucco, north of Greybull, there is about 80 feet of red shale and buckshot iron ore, with a 6-foot bed of sandstone near the base.

The beds numbered 10 to 13 in the section are set off by unconformity above, and are possibly separated from the Sacajawea by unconformity below. These beds may be added to the Sacajawea if favoring evidence appears, but there is a possibility that they may be equivalent to the Chester beds of the Brazer formation of Idaho. The upper part of the Amsden formation is not separable from the Tensleep sandstone on available evidence.

The species now known from the Sacajawea formation, excepting the ostracodes described by Morey, are given in the following list. Species identified by Branson and Greger are indicated by asterisks.

Fauna of the Sacajawea Formation
Clionolithes pricei Branson, n. sp.
**Zaphrentis amsdenensis* Branson and Greger
**Chaetetes*? sp.
Spirorbis moreyi Branson, n. sp.
**Ortonia* cf. *blatchleyi* Beede
Archeocidaris spines and plates
*Crinoid stem ossicles
Batostomella cf. *spinulosa* Ulrich
Rhombopora sp.
Fenestella sp.
Polypora sp.
Anisotrypa cf. *fistulosa* Ulrich
**Orbiculoidea wyomingensis* Branson and Greger
Rhipidomella gregeri Branson, n. sp.
**Schizophoria swallowi*? Hall
**Orthotetes kaskaskiensis* (McChesney)
Streptorhynchus poposiensis Branson, n. sp
**Meekella amsdenensis* Branson and Greger
**Chonetes chesterensis* Weller
Chonetes suttoni Branson, n. sp.
Linoproductus croneisi Branson, n. sp.
**Pustula genevievensis* (Weller)
**Productus phillipsi* (Norwood and Pratten)
**Tetracamera subcuneata* (Hall)
**Pugnoides ottumwa* (White)
Selenella? *walteri* Branson, n. sp.
?*Girtyella indianensis* (Girty)
**Spirifer welleri* Branson and Greger
**Spirifer pellaensis* Weller
**Spirifer shoshonensis* Branson and Greger
**Martinia* sp.
**Punctospirifer browni* (Branson and Greger)
**Eumetria verneuiliana* (Hall)
**Cliothyridina hirsuta* (Hall)
**Composita trinuclea* (Hall)
Composita blackwelderi Branson, n. sp.
**Myalina sancti-ludovici* Worthen
**Microdon* cf. *oblongus* (Hall)
**Paleoneilo amsdenensis* Branson and Greger
Conocardium orientale Branson, n. sp.
Nucula sp.
Schizodus sp.
**Loxonema wortheni* Weller
**Bulimorpha bulimiformis* (Hall)
Ptychomphalus wortheni Weller
Solenospira pygmaea Weller
Strophostylus sp.
Euphemites sacajawensis Branson, n. sp.
Bucanopsis sp.

Plagioglypta? sp.
**Orthoceras*? sp.
**Cycloceras*? sp.
Leperditia carbonaria? Hall
Griffithides moorei Branson, n. sp.
Acanthodes (*Holmesella*) n. sp.
Multidentodus sp.
Scolopodus? sp.
Conical denticles

Of these species, *Composita trinuclea*, *Eumetria verneuiliana*, *Spirifer pellaensis*, *Pugnoides ottumwa*, *Orthotetes kaskaskiensis*, *Loxonema wortheni*, *Girtyella indianensis*, *Solenospira pygmaea*, *Ptychomphalus wortheni*, and *Leperditia carbonaria* occur in Ste. Genevieve beds of the Mississippi Valley. The Ste. Genevieve also has species of *Streptorhynchus*, *Conocardium*, *Nucula*, *Bulimorpha*, *Spirorbis*, and *Clionolithes* similar to Sacajawea forms, and the two faunas are strikingly alike in facies. *Ortonia blatchleyi*, *Tetracamera subcuneata*, *Girtyella indianensis*, *Eumetria verneuiliana*, *Composita trinuclea*, *Bulimorpha bulimiformis*, and species similar to Sacajawea species in other genera occura in the Salem limestone. Several Sacajawea species are found in the St. Louis limestone. The Chester faunas, on the other hand, are quite different. The Sacajawea fauna is conspicuous in its complete lack of blastoids, which are so characteristic of upper Mississippian faunas in the Mississippi Valley. It may be concluded that the Sacajawea formation is Salem to Ste. Genevieve in age, closer affinities being with the Ste. Genevieve, possibly because of greater similarity in facies.

The Spergen facies of the Brazer limestone of Idaho and Utah has a number of species in common with the Sacajawea: *Spirifer pellaensis*, *Composita trinuclea*, *Cliothyridina hirsuta*, *Eumetria verneuiliana*, and *Bulimorpha bulimiformis*. There are many other close affiliations between the faunas. The Chester facies of the Brazer yields the Sacajawea species *Pustula genevievensis*, *Composita trinuclea*, *Spirifer pellaensis*, and *Productus elegans* (similar to *P. phillipsi*). The Sacajawea correlates with the Brazer, at least in part.

A Mississippian fauna from the Big Snowy Mountains, Mont., listed as from the Quadrant quartzite and identified by Girty (1931) is from lower beds. Scott (1935) has recently restudied the rocks called Quadrant and has recognized Amsden beds beneath them on Quadrant Mountain in Yellowstone Park and in south-central Montana. The lower portion of these beds is Sacajawea and contains upper Mississippian fossils. The Kibbey of the Little Belt and Big Snowy Mountains appears to be of the same age. The upper Mississippian becomes thicker in central Montana by the wedging in of the Big Snowy group, which may be in part equivalent to the Sacajawea and which probably includes beds of Chester age.

The types of species described in this paper are deposited in the paleontological collections of the University of Missouri. Most of the specimens were collected by members of the faculty and by students of that institution.

SYSTEMATIC PALEONTOLOGY

Phylum ANNELIDA

Genus SPIRORBIS Daudin

SPIRORBIS MOREYI Branson, n. sp.

Plate 89, figures 1, 2

This species is represented by ten specimens, two of which are cemented to fragments of shell. Shell a low spiral coil of four volutions, terminating in a straightening twist upward in the region of the aperture. The spire is almost plane in most specimens, entirely flat in cemented ones; aperture oval; umbilicus deep, with moderately steep slopes. Surface of shell marked by fine revolving ribs, about 60 in all, which are crossed by growth lines more widely spaced than the ribs and nearly as high, so that the shell surface is divided into rectangles on the outer part of the whorls and into rhombs on the sides. Near the aperture the growth lines are large, irregular and closely spaced. An average specimen is 2 mm. in diameter, 1.2 mm. high, and the straight apertural part of the tube is 0.6 mm. long.

Remarks.—The species does not closely resemble any described form, although *Spirorbis* is abundant in the Salem and occurs in the Ste. Genevieve and Pella. The species is named for P. S. Morey who collected some of the smaller fossils.

Phylum PORIFERA

Genus CLIONOLITHES Clarke

CLIONOLITHES PRICEI Branson, n. sp.

Plate 89, figure 3

The shells of many specimens of Sacajawea brachiopods are pierced by sponge borings. The borings are about 0.2 mm. in diameter and nearly uniform. Most of them penetrate the shell to a depth of approximately a millimeter and parallel the surface at that depth, but some penetrate considerably deeper. The borings are 2 to 6 mm. long; the majority are straight and terminate within the shell, but some come to the surface again. Borings are most abundant in shells of *Diaphragmus phillipsi*, in which they enter the shell through broken spine bases, in some cases two or three through a single spine base. Most of the borings lie parallel to and beneath plications. Specimens noted in shells of *Composita trinuclea* and *Cliothyridina hirsuta* are irregular in direction and in depth of penetration and are gregarious.

It is apparent that the shells lay on the sea bottom and were broken by wave action before burial. The sponges bored into shells of *Diaphragmus* after the spines were broken off. Many Sacajawea specimens show evidence of contemporary breakage and crushing.

Remarks.—The species is not unlike *C. lizardensis* Lees and Thomas, from the Ste. Genevieve limestone of Iowa, which is sinuous and more gregarious. It is similar to *C. canna* Price of the Pottsville of West Virginia, but is straighter and not matted. *C. priscus* (McCoy) of the Devonian also follows plications, but is larger and more club-like. The species is named for A. S. Price, fellow collector in the Wind River area for several seasons.

Phylum ECHINODERMA

Class ECHINOIDEA Brown

Plate 89, figures 4, 5

Isolated echinoid plates and spines are numerous. The plates are hexagonal and are minutely marked by hexagonal pits. The pits cover the entire plate except the mamelon, those on the areola being larger and elongated. The spines are finely striated longitudinally and are marked into squares by less conspicuous transverse ridges. A single specimen of a stout clavate spine with pointed nodes was collected.

Class CRINOIDEA Miller

Crinoid columnals are reasonably common, but no other crinoid remains have been found.

Phylum BRYOZOA

Plate 89, figures 6, 7

Bryozoa are scarce and are in most cases poorly preserved. Small ramose

forms occur in microscopic material and are referred to *Rhombopora*. An encrusting *Anisotrypa* is found on shell fragments. *Fenestrellina* and *Polypora* are represented by numerous broken specimens. A large ramose form occurs in the limestone on Bull Lake Creek, but the external characteristics are destroyed. On the basis of thin sections, this species is referred to *Batostomella* and is close to *B. spinulosa* Ulrich.

Phylum BRACHIOPODA

Genus ORBICULOIDEA d'Orbigny

ORBICULOIDEA WYOMINGENSIS
Branson and Greger
Plate 89, figure 34

Additional specimens permit further description of the ornamentation. Both valves are marked by regularly spaced sharp concentric ridges and by fine growth lines. The ridges are especially strong on the slopes of the pedicle furrow and are indistinct on the central portion of the pedicle valve. Faint radial striae are discernible in this region.

Genus RHIPIDOMELLA Œhlert

RHIPIDOMELLA GREGERI
Branson, n. sp.
Plate 89, figures 16, 17

Shell nearly circular, slightly longer than wide, greatest width near the front margin. Pedicle valve convex, especially in umbonal region; beak sharp, produced; posterior margin straight; hinge straight, short, hardly one-third as long as the shell width; cardinal area small, triangular; delthyrium large, open; a shallow sinus extends along anterior two-thirds of valve, notching anterior margin slightly; surface of valve marked by 24 radial striations which increase by bifurcation and intercalation, outer slopes of the sinus bearing one striation near the crest and another at the crest. Brachial valve slightly convex, beak sharp, elevated, produced over the hinge; posterior margin nearly straight; anterior slope plane or slightly concave, bearing a small but distinct fold near anterior margin, the plane area bounded by broad rounded shoulders; surface of valve marked by 26 striations of which the inner pair terminate on the fold, and by closely spaced growth lines.

An average specimen is 0.8 mm. long, 0.7 mm. wide, and 0.4 mm. high. The species resembles *R. perminuta* Girty from the San Saba region, Tex., but may be distinguished by the fold in the plane area of the brachial valve. The species is named in honor of D. K. Greger.

Genus STREPTORHYNCHUS King

STREPTORHYNCHUS POPOSIENSIS
Branson, n. sp.
Plate 89, figures 10–12

Pedicle valve convex, twice as wide as long, greatest width in front of hinge; posterior margin straight with angular corners; beak strongly curved over hinge, the beak and a portion of umbonal region projecting past the posterior margin; cardinal area high, at right angles to plane of valve; a triangular deltidium closes the delthyrium; surface of umbo smooth, rest of shell surface being marked by radial striae, 16 at mid-length, increasing by intercalation to anterior margin; striations sharp, separated by deep furrows narrower than the striations. Brachial valve slightly convex, widest in front of umbo; hinge straight, with sharp corners; beak elevated, straight, not produced beyond hinge; a small area at the beak is smooth, rest of the surface being marked by sharp striations which begin near the beak and increase by intercalation to 16 at mid-length, additional striations being introduced between the central striations near front margin. The surface of both valves is closely reticulated by fine growth lines across the striations. The larger syntype is 1 mm. wide and 0.5 mm. long.

Remarks.—The species resembles *S. minutum* (Cumings) of the Salem limestone but is smaller (the largest Sacajawea specimen is no larger than a small immature Salem specimen) and has fewer striations. The specific name is taken from a local spelling of Popo Agie, the river near which the collections were made.

Genus CHONETES Fischer

CHONETES SUTTONI Branson, n. sp.
Plate 89, figures 8, 9

Shell concavo-convex, subquadrate, wider than long, widest at the hinge. Pedicle valve convex, beak straight, produced beyond the hinge; hinge straight, with angular corners; umbonal region nearly plane, slope being moderate in middle portion of length and steep near anterior margin; a deep sinus that begins at mid-length is 6 mm. wide at front margin; cardinal area as long as hinge, inclined 120 degrees to plane of valve, smooth, slightly concave near beak, about 2 mm. high; posterior edge of valve bears three nodose elevations on each side of beak; surface of valve closely striated; the striations, which number about 8 per millimeter, increase by intercalation and bifurcation, and are indistinct on posterior corners of valve. Brachial valve concave, plane in umbonal region; beak small; cardinal area about 1 mm. high; ornamentation not preserved; the valve bears a broad low fold on the anterior third of its length. The holotype is 13 mm. long, 20.5 mm. wide, 19.5 mm. wide at mid-length, and 3.4 mm. high.

Remarks.—*C. oklahomensis* Snider from the Chester is similar but does not have a straight hinge. *C. chesterensis* Weller is not so closely striated and lacks a fold and sinus.

Genus LINOPRODUCTUS Chao

LINOPRODUCTUS CRONEISI Branson, n. sp.
Plate 89, figures 13–15

Pedicle valve moderately convex, widest near mid-length; beak pointed and produced; hinge straight, almost as long as width of shell, nearly square at corners; lateral posterior corners turned from plane of valve; an irregular row of 5 or 6 posteriorly directed spines lies along posterior margin on each side of beak, and a second row of 2 or 3 spines

---

EXPLANATION OF PLATE 89

FIGS. *1, 2*—*Spirorbis moreyi* Branson, n. sp. *1*, Ventral view of a paratype, ×14; *2*, ventral view of holotype, ×14. (p. 654)

3—*Clionolithes pricei* Branson, n. sp. Drawing of boring in shell of *Productus phillipsi* entering through broken spine base, ×4. (p. 654)

4—Echinoid spine, ×1. (p. 654)

5—*Archeocidaris* sp., interambulacral plate, ×2. (p. 654)

6—*Polypora* sp., fragment of a colony, ×5. (p. 654)

7—*Batostomella* cf. *B. spinulosa* Ulrich, vertical section, ×7. (p. 654)

8, 9—*Chonetes suttoni* Branson, n. sp. *8*, Ventral valve of holotype, ×2; *9*, dorsal valve of holotype, ×1. (p. 656)

10–12—*Streptorhynchus poposiensis* Branson, n. sp. *10*, Dorsal view of holotype, ×5; *11*, ventral view of a small paratype, ×5; *12*, posterior view of a paratype, ×14. (p. 655)

13–15—*Linoproductus croneisi* Branson, n. sp. *13*, Ventral view of holotype, ×2; *14*, lateral view of a paratype, ×2; *15*, dorsal view of same paratype, ×2. (p. 656)

16, 17—*Rhipidomella gregeri* Branson, n. sp. *16*, Dorsal view of holotype, ×14; *17*, ventral view of paratype, ×6. (p. 655)

18–20—*Composita blackwelderi* Branson, n. sp. *18*, Dorsal view of holotype, ×5; *19*, ventral view of a paratype, ×5; *20*, posterior view of a paratype, ×5. (p. 657)

21, 22—*Selenella? walteri* Branson, n. sp. *21*, Dorsal view of holotype, ×14; *22*, ventral view of paratype, ×15. (p. 657)

23—*Conocardium orientale* Branson, n. sp. Right valve of the holotype, ×5. (p. 657)

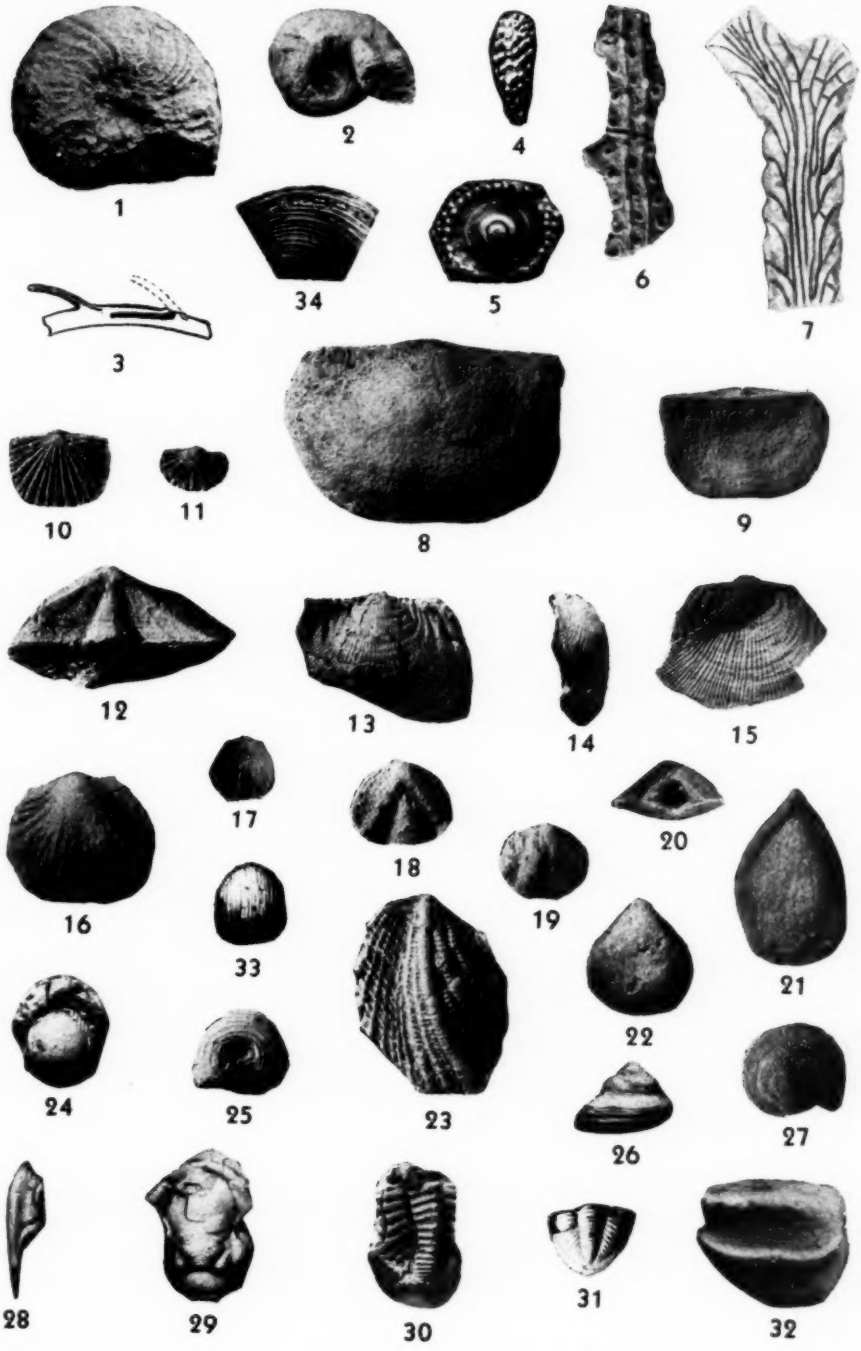
24, 25, 33—*Euphemites sacajawensis* Branson, n. sp. *24*, Apertural view of paratype, ×2; *25*, view of the holotype, ×2; *26*, lateral view of a paratype, ×2. (p. 658)

26, 27—*Ptychomphalus wortheni* Weller. *26*, Lateral view of a specimen, ×2; *27*, dorsal view of another specimen, ×2. (p. 658)

28–31—*Griffithides moorei* Branson, n. sp. *28*, View of the allotype free cheek, ×2; *29*, view of a cephalon, the holotype, ×2; *30*, view of the holotype reversed, showing the thorax and pygidium, ×2; *31*, view of an allotype pygidium, ×2. (p. 659)

32—*Acanthodes*, n. sp. Lateral view of a large specimen, ×15. (p. 660)

34—*Orbiculoidea wyomingensis* Branson and Greger. Portion of a ventral valve showing the ornamentation, ×2. (p. 655)



C. C. Branson, Mississippian Fossils from Wyoming

UNIV. OF MICH.

on each side of beak lies immediately in front of the first row; surface of valve bears fine rounded plications, 5 to a millimeter, which increase by intercalation; plications weak on the ears and obsolete near and in the area of the spines; the shell also bears concentric undulations and fine growth lines, both of which are especially distinct in the spinose area. Brachial valve deeply concave, corners plane to convex, sharply angular; beak slightly elevated, convex; hinge straight, shell sharply folded upward along hinge; surface marked by plications similar to those of pedicle valve, but these increase by bifurcation rather than by intercalation; plications obsolete on posterior portion of the ears, where fine growth lines are distinct; entire shell surface bears concentric wrinkles and fine growth lines.

The holotype is 10.5 mm. wide and 10 mm. long, but is incomplete. *L. croneisi* does not closely resemble any other species of comparable age.

Genus SELENELLA Hall and Clarke

SELENELLA? WALTERI Branson, n. sp.
Plate 89, figures 21, 22

More than 100 specimens of a minute brachiopod in our collections resemble *Selenella* in shape and in character of the hinge. Shell almond-shaped, pointed at beaks, longer than wide, greatest width at mid-length. Pedicle valve strongly convex in umbonal region, less so anteriorly; beak sharp, produced, extending far past the hinge and overhanging the brachial valve; cardinal area high, triangular, with large open delthyrium; hinge one-third as long as width of shell. Brachial valve subcircular, moderately convex; beak small; posterior corners of valve plane. Surface of both valves marked by inconspicuous growth lines and by fine punctae which appear to be arranged in quincunx. An average specimen is 1.5 mm. long, 1 mm. wide, and about 0.5 mm. high.

Remarks.—The species resembles *S.? subcircularis* Girty from the San Saba region of Texas. It differs in its smaller size, sharper beaks and plane posterior corners. The species is named for Glenn Walter, who collected many of the smaller species.

Genus GIRTYELLA Weller

?GIRTYELLA INDIANENSIS (Girty)

A single incomplete specimen suggests this species in shape and minute punctation.

Genus COMPOSITA Bronn

COMPOSITA BLACKWELDERI Branson, n. sp.
Plate 89, figures 18–20

Shell small, nearly triangular, about as wide as long, greatest width at mid-length. Pedicle valve highly convex, highest near beak which is produced, turned sharply down and past the posterior margin; hinge about one-third as long as width of shell; cardinal area high, triangular; delthyrium large, open; a deep sinus extends along center of valve on anterior two-thirds of its length, being bounded by high rounded folds; outside of the folds is a pair of broad shallow grooves bounded by low ridges, these grooves and ridges being indistinct in some specimens. Brachial valve nearly plane to slightly convex, posterior corners angular; beak distinct, produced; a high, fairly sharp fold lies opposite the sinus of the opposite valve and is flanked throughout its length by a pair of deep rounded grooves. Surface of both valves marked only by fine growth lines. An average specimen is 1.2 mm. long, 1.2 mm. wide, and 0.9 mm. high.

Remarks.—The species resembles *C. opposita* (White and Whitfield), but the sinus is broader and not so long. The species is named in honor of Eliot Blackwelder, who has contributed so much to Wyoming stratigraphy.

Phylum MOLLUSCA

Class PELECYPODA

Genus CONOCARDIUM Bronn

CONOCARDIUM ORIENTALE Branson, n. sp.
Plate 89, figure 23

The holotype is an incomplete shell from which the anterior and posterior

portions are missing. Each valve with raised median area ornamented near beak by two nodose ribs, a third rib being intercalated at mid-height, and a fourth, but weak, rib near ventral margin; anterior portion bears four nodose ribs and a fifth, intercalated near the inner rib at mid-height, which is weak and lies near and inside the fourth rib; posterior slope bears eight or more ribs, and two more are intercalated at mid-height; ribs of the posterior area not as strong as those of remainder of shell, and, because growth lines are nearly as pronounced as the ribs, the shell surface is divided into a network of rhombs; beaks curved inward and inclined anteriorly. The holotype is 2.8 mm. long, 3.4. mm. high, and 2.4 mm. wide, but the true length is probably nearly twice as great.

Remarks.—The species resembles *C. mesialis* Weller of the Ste. Genevieve in its possession of a raised median area, but is smaller and has fewer ribs on the median area.

Genus Nucula Lamarck

Nucula sp.

Several specimens of *Nucula* are in our collections, but none retain the shell. An abundance of small internal molds seem to be of the same species.

Genus Schizodus King

Schizodus sp.

The Sacajawea form is quite similar to *S. chesterensis* Meek and Worthen, but our specimens are not sufficiently well preserved for specific identification.

Class Gastropoda

Genus Soleniscus Meek and Worthen

Soleniscus (Bulimorpha) bulimiformis (Hall)

This form was referred to *B. caniculata* (Hall) by Branson and Greger, but is higher, more slender, and lacks the channeled suture and sharp carina on the last whorl. The Sacajawea forms are marked by very fine growth lines, and differ from Hall's description of *B. bulimiformis* in being even more finely marked by transverse lines, which become fairly distinct near the aperture and parallel the inner lip along its lower edge. The form is not so slender and has fewer whorls than *B. elegans* Girty from the Brazer limestone of Idaho. A specimen with the first two or three volutions missing is 14.4 mm. long.

Genus Ptychomphalus Agassiz

Ptychomphalus wortheni Weller

Plate 89, figures 26, 27

The Sacajawea specimens agree in minute detail with this Ste. Genevieve species.

Genus Solenospira Ulrich and Scofield

Solenospira pygmaea Weller

Solenospira pygmaea Weller, *1916*, Univ. Chicago, Walker Mus., Contr., vol. 1, p. 256, pl. 18, figs. 1–5.

Our specimens differ from Weller's species in having as many as ten revolving ribs on each volution, but the extra number may be exposed by the breaking away of the shell near the sutures.

Genus Strophostylus Hall

Strophostylus sp.

Two steinkerns are referred to this genus.

Genus Euphemites Warthin

Euphemites sacajawensis Branson, n. sp.

Plate 89, figures 24, 25, 33

Several specimens with preserved ornamentation show that the specimen figured by Branson and Greger as *Bucanopsis* or *Bellerophon* is a new species of *Euphemites*. Whorl oval in outline, the dorso-ventral diameter greater than the lateral diameter. Surface of last whorl marked by 22 revolving carinae, which are narrow, even, rounded at the top, separated by shallow furrows each about four times the width of a carina; growth lines parallel the outer lip and the slit, dividing the lateral slopes into diamonds as they cross the carinae obliquely. Aperture moderately flaring; slit deep, rounded at the corners. Slit-

band broad, bearing three carinae; bounded by two carinae which extend nearer the aperture than other carinae. Umbilicus deep and steep-sided. An average shell is 9 mm. in diameter. A number of minute steinkerns agree with this species in shape.

Remarks.—This species resembles *E. carbonarius* (Cox) in the number and arrangement of carinae, but is smaller, more slender, and lacks nodes on the lateral carinae.

Genus BUCANOPSIS Ulrich

BUCANOPSIS sp.

Two steinkerns have the general shape and the characters of the slit-band of *Bucanopsis*.

CLASS SCAPHOPODA

Genus PLAGIOGLYPTA Pilsbury and Sharp

PLAGIOGLYPTA? sp.

Fragments of internal molds which appear to belong to this genus are fairly abundant.

Phylum ARTHROPODA

Class OSTRACODA

Genus LEPERDITIA Roualt

LEPERDITIA CARBONARIA? Hall

One poorly preserved shell appears to belong to this common species. Morey reported 17 species of ostracodes from the Sacajawea beds, of which all but one were new.

Class TRILOBITA

Genus GRIFFITHIDES Portlock

GRIFFITHIDES MOOREI Branson, n. sp.
Plate 89, figures 28–31

This species is represented in the collections by a cephalon lacking the free cheeks, a detached free cheek, several pygidia, and five detached genal spines. Cephalon semicircular in outline, frontal border with 8 longitudinal lines on the dorsal side; frontal depression anterior to glabella slight. Glabella large, pear-shaped in outline, with an indistinct pair of furrows near the posterior end; a pair of lateral posterior lobes are entirely set off from the glabella by deep oblique furrows; lobes conical, with a low oblique ridge extending to the center of the palpebral lobes; occipital lobe pronounced, with a deep occipital furrow; it bears 12 irregularly placed nodes along its posterior edge and a single central node just behind the central point of the lobe. Palpebral lobes elevated and set off from the glabella by a broad furrow. Surface of higher part of glabella, palpebral lobes and occipital lobe pustulose; the postero-lateral lobes bear five large pustules, and the pustules of the posterior part of the glabella behind the furrows are large.

The eye is a broad semicircular band of ommatidia, preserved in the holotype as a mold of the base. The free cheek bears a long pointed genal spine which has a sharp inner edge and a more rounded outer edge; a smooth triangular depression lies on the upper surface of the proximal part as a continuation of the lateral marginal furrows; surface of spine, except for the triangular proximal area and the inner third of the ventral side, marked by longitudinal lines which increase by intercalation. These lines are continuous with similar lines on the free cheek and the frontal margin and on the marginal band on the ventral side of the cephalon.

The eight posterior thoracic segments preserved in the holotype are ornamented along the posterior margin of the axial lobe by a row of nodes. Pygidium of 18 segments; anterior segments of axial lobe marked by posterior row of nodes, posterior segments marked by irregular nodes. Pygidial doublure broad, marked along the anterior lateral margin by continuations of the longitudinal lines on the ventral margin, which are like those of the cephalon. The postaxial ridge is low, triangular, apex at the posterior margin; postaxial furrows distinct.

The cephalon is 10.8 mm. long, genal spine 5 mm. long, average pygidium 5.3 mm. long, 6.5 mm. wide. There are probably no more than nine thoracic segments.

Remarks.—*G. moorei* belongs to the genus *Griffithides* as emended by J. M. Weller (1937). It resembles *G. pustulosus* Snider of the Chester of Oklahoma, but is smaller, has fewer pygidial segments, has nonpustulose areas on the cephalon, the glabella is less expanded anteriorly, and the basal lobes are smaller and sharper. The species is named in honor of Raymond C. Moore, who found the holotype.

Phylum CHORDATA

Class CHONDRICHTHYES

Order ACANTHODII

Family ACANTHODIDAE

Genus ACANTHODES Agassiz

ACANTHODES, n. sp.
Plate 89, figure 32

Shagreen granules of *Acanthodes* are rare in microscopic material and only three specimens have been collected. The enamel surface in these is nearly plane, almost square, marked by a pattern of concentric chevrons; sides of crown concave, one side markedly so, concave sides bounded below by a well-marked ridge. The base tapers to a high rounded apex beneath one corner of the crown, and is marked by lines concentric about that point. The largest specimen is 0.5 mm. high and 0.6 mm. wide.

Remarks.—The species is similar to *Acanthodes quadrata* (Gunnell), the genotype of *Holmesella*, from the Fort Scott, limestone, but the base is more nearly symmetrical and the sides of the crown are concave. The genus *Holmesella* applies to the shagreen granules of *Acanthodes* and is a strict synonym of that genus. The pattern on the surface of shagreen granules differs according to amount of erosion and granules are variable over the body of an individual. *A. wapanuckensis* (Harlton) appears to differ only in this degree from *A. triangularis* (Harlton), both from the John's Valley shale of Oklahoma (generic name spelled *Holmsella* in explanation of Plate 3). Harlton's species and *A. equilaterata* (Gunnell) appear to be conspecific with *A. marshi* Eastman from Mazon Creek, Ill.

The Sacajawea also yields a *Multidentodus*, conical shagreen granules, and ridged cones of the type which Gunnell referred to *Scolopodus*. Dermal elements of many kinds are abundant from Ordovician to Permian, but they do not show consistent variation. Some types are hardly distinguishable from modern shark shagreen granules. Paleontologists should limit the creation of species to forms that differ distinctly in significant structures and which have decided stratigraphic significance.

REFERENCES

BLACKWELDER, E., *1913*, New or little known Paleozoic faunas from Wyoming and Idaho: *Am. Jour. Sci.*, 4th ser., vol. 36, pp. 174–179.

BRAINERD, A. E., and KEYTE, I. A., *1927*, New faunal evidence from the Tensleep formation (Wyoming): *Jour. Paleontology*, vol. 1, pp. 173, 174.

BRANSON, E. B., and GREGER, D. K., *1918*, Amsden formation of the east slope of the Wind River Mountains of Wyoming and its fauna: *Geol. Soc. America, Bull.*, vol. 29, pp. 309–326.

DARTON, N. H., *1906*, Geology of the Bighorn Mountains: *U. S. Geol. Survey, Prof. Paper* 51, pp. 31–34.

———, *1908*, Paleozoic and Mesozoic of central Wyoming: *Geol. Soc. America, Bull.*, vol. 19, pp. 414, 415.

GIRTY, G. H., in REEVES, F., *1931*, Geology of the Big Snowy Mountains, Montana: *U. S. Geol. Survey, Prof. Paper* 165, p. 143.

LEE, W. T., *1927*, Correlation of geologic formations between east-central Colorado, central Wyoming and southern Montana: *U. S. Geol. Survey, Prof. Paper* 149.

MOREY, P. S., *1935*, Ostracoda from the Amsden formation of Wyoming: *Jour. Paleontology*, vol. 9, pp. 474–482.

SCOTT, H. D., *1935*, Some Carboniferous stratigraphy of Montana and northwestern Wyoming: *Jour. Geology*, vol. 43, pp. 1011–1032.

C. C. BRANSON, BROWN UNIVERSITY, PROVIDENCE, RHODE ISLAND. MANUSCRIPT RECEIVED BY THE EDITOR FEBRUARY 10, 1937.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 8, PP. 661–697, PLS. 90–92, DECEMBER, 1937

FORAMINIFERA OF THE MIDDLE TERTIARY CARAPITA FORMATION OF NORTHEASTERN VENEZUELA

H. D. HEDBERG

ABSTRACT

A large fauna of Foraminifera from the Carapita formation, about 9,000 feet thick, in northeastern Venezuela, is described. New species of *Bathysiphon, Ammodiscus, Textularia, Heterostomella?, Rzehakina, Sigmoilina, Planularia, Marginulina, Nodosaria, Saracenaria, Bulimina, Uvigerina, Valvulineria, Eponides, Cassidulina, Globigerina, Anomalina* and new varieties of *Bolivina* are described. Detailed consideration of the environment of deposition leads to the conclusion that the Carapita sediments were laid in rather deep but quiet water; also, it is believed that facies is more important than geologic age in determining the composition of a Tertiary foraminiferal fauna. Correlations with described foraminiferal deposits of surrounding territory are discussed.

The outcrop area of the Carapita formation of northeastern Venezuela lies in the District of Libertad, State of Anzoategui. The type section is exposed north of the town of Santa Ines on Quebrada Carapita, a small tributary of the Rio Querecual (fig. 1). Other outcrop sections are known on the Rio Querecual to the west and on the Rio Aragua and Rio Oregano to the east, but these are not as complete as the type.

The formation, in the type section, consists of a lower sandy shale and sandstone member, about 2,000 feet thick, and an upper shale member, about 7,000 feet thick. It occupies a belt of relatively low relief, some 3 kms. wide, between upper Eocene sandstones of the Merecure formation on the north and prominent sandstone and conglomerate ridges of middle Miocene age belonging to the Santa Ines formation on the south. Dips range from nearly vertical to 60° N. (overturn). Outcrops are by no means continuous; actually, less than half of the formation is exposed. In the type section the formation bears a sharp angular relation to the overlying Santa Ines formation, although from a regional viewpoint the two are to a large extent laterally intergradational. Definite evidence of an unconformity between the Carapita beds and the underlying Merecure formation is not yet available, although it is probable that such a relation exists.[1]

Megascopic fossils have not yet been found in the Carapita formation of the type locality, but Foraminifera are fairly common and locally abundant. These are particularly concentrated in both variety and abundance in a middle zone from 3,000 to 5,000 feet above the base of the formation. In the lower 3,000 feet of the formation Foraminifera are rather scarce

[1] The general stratigraphy of the geologic section exposed on the Rio Querecual and its tributaries is discussed in detail in a paper entitled "Stratigraphy of the Rio Querecual section of northeastern Venezuela" which is awaiting publication in the *Bulletin of the Geological Society of America*. Reference should be made to this other paper for data on lithology, mineralogy, formation boundaries, stratigraphic relations, and correlation of the Carapita formation, and for a graphic columnar section of the formation.

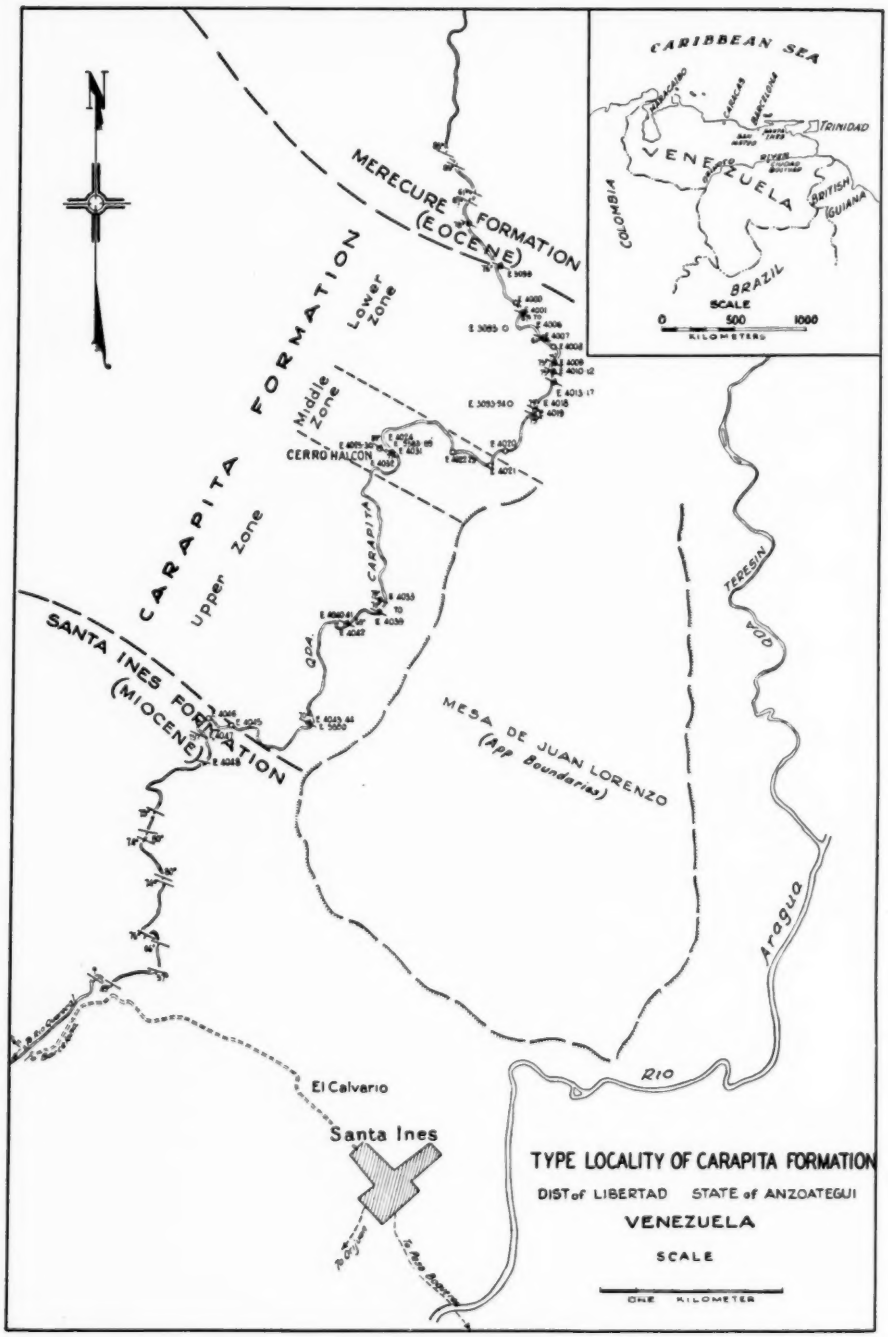


FIG. 1.—Type locality of the Carapita formation.

and largely limited to arenaceous forms. They are also rather scanty in samples from the upper 4,000 feet of the formation. Because of the large gaps between samples it is not yet possible to draw sharp zonal divisions, but approximate boundaries are indicated on the accompanying sketch map (fig. 1).

The purpose of the present paper is to put on record the foraminiferal fauna of the type Carapita formation and to establish its approximate stratigraphic position through comparison with other fossil faunas of tropical America. No attempt has been made to cover all Foraminifera that are present in the Carapita formation. The species described or mentioned here are largely those that are common in the type section, of particular stratigraphic importance, or are otherwise especially interesting. A more varied, abundant, and better-preserved fauna is found in the formation of the Rio Oregano, about 15 kms. east of the type section, and a few additional species from this locality have been included in the descriptions given here.

The distribution of species in samples from the type locality is given in Table I. The locations of individual samples are shown on the sketch map (fig. 1), and their relative stratigraphic positions will be shown in the graphic columnar section of the Carapita formation which accompanies my paper on the general stratigraphy of this area. Almost all species identified in the Venezuelan material have been compared either with holotypes or topotypes of the species to which they have been referred. Also, material has been examined from most of the localities in tropical America from which other published foraminiferal studies have been made. Complete synonymies are not given, but the original reference to each species has been cited and an attempt has been made to give references to all other published occurrences in tropical America.[2] Significant occurrences in related regions, such as California, the Gulf Coast, and Florida, are also mentioned. Holotypes of all new species and varieties have been deposited in the Cushman Laboratory in Sharon, Mass., and sets of topotypes are on file at Stanford University in California and at the Geological Laboratory of the Venezuela Gulf Oil Company in Maracaibo, Venezuela.

Acknowledgments.—My study of the Foraminifera of the Carapita formation was begun in the Geological Laboratory of the Venezuela Gulf Oil Company in Maracaibo, Venezuela, in 1933, and it is with the permission of that company and through the courtesy of William Wallace, vice-president; C. M. Crebbs, general agent; P. E. Nolan, chief geologist in Venezuela; and E. S. Bleecker, staff geologist in New York, that the present paper is published. The study was continued at Stanford University in 1935,

[2] Because of the impossibility of verifying identifications, references have not been given in the synonymies to species mentioned in lists such as those of Guppy, R. J. L., The microzoa of the Tertiary and other rocks of Trinidad and the West Indies: *Field Naturalists' Club, Jour.*, Dec., 1893, pp. 285–290 (Reprinted, *Bull. Am. Paleontology*, vol. 8, no. 35, pp. 121–126, 1921), and Chapman, Frederick, Appendix on the Foraminifera from Bissex Hill and Bowmanstown (Barbados): *Geol. Soc. London, Quart. Jour.*, vol. 54, 1898, pp. 550–555.

TABLE 1.—*Distribution of foraminiferal species in samples from the type section of the Carapita formation on Quebrada Carapita.*

	LOWER ZONE								MIDDLE ZONE												UPPER ZONE					
	E-4000	E-4008	E-4009	E-3093	E-3094	E-4013 to E-4014	E-4015	E-4016	E-4080	E-4083	E-4082	E-4081	E-4084	E-4030	E-4085 to E-4087	E-5565 to E-4567	E-4088	E-5566	E-4089	E-4058	E-4033 to E-4034	E-4035, E-4036	E-4039	E-4040, E-4041	E-4042	E-4043, 4044, 5560	E-4045
Ammobaculites sp.													S								R	R					S
Ammodiscus incertus [d'Orbigny]							R					C							R	S							C
Ammodiscus pariauus Hedberg		R	R	R					R	R			S		S	A				R	S	S			S		
Anomalina mecatepecensis Nuttall																				R							
Anomalina nolani Hedberg						R								R				C	S	C							
Anomalina pariana Hedberg			C	S	S	C																					
Bathysiphon carapitanus Hedberg		C	S	R	C	R		S	C	C	C	S	R	S	C	R				R		S	C	S	S	C	
Bolivina semariensis (Costa) var. carapitana Hedberg		S				R								S	C	C					C	C					S
Bolivina elazanensis Cushman var. venezuelana Hedberg			R	R		R							R		R			A	C	A	R				C	
Bulimina bleickeri Hedberg			R		S	S				S	S							R	R	R	S					S	
Bulimina cf. inflata Seguenza										S											S						
Bulimina pupoides [?] d'Orbigny											S									R							
Cassidulina carapitana Hedberg			R	S	R	S				R	S	R															
Cassidulina subglobosa Brady										R		S		R				S	C	R	R				R		
Chilostomella oolina Schwager						R				S	R					R				C							
Clavulina curta Galloway and Morrey						R				S						R			R	R	R						
Cibicides americanus (Cushman)								R									S			R							
Cibicides floridanus (Cushman)																		R	C	R							
Cibicides mantaensis (Galloway & Morrey)		R	S	S		S				C	W	C															
Cyclammina cancellata Brady		C								C	C	C		R		S	R	S		C					C		
Dentalina adolphina d'Orbigny												R				R				R							
Dorothia sziphonia (Andreae)																		R		C							
Dorothia nuttalli Cushman																		R	R	S							
Ellipsonodoseria verneuili (d'Orbigny)					S	S	S							S		S	S	A	C	A							
Eponides byramensis Cushman														R		R		C	S	S		R					
Eponides crebbsi Hedberg							R			C	S	S		R		R		R	S	C				R			
Eponides umbonatus (Reuss) var. ecuadorensis Galloway and Morrey											R	S						R		R							
Caudryina jacksonensis Cushman											R							R		S							
Globigerina sp.		S	R		S	R		R	C	A	S		R	S	R	S	S	S	S	C	S	C				S	R
Globigerina venezuelana Hedberg																	R			S							
Globigerinella sp.			R							S	R	R					R			C	S						
Globobulimina cf. pacifica Cushman					R			R	S	S	R							R							R		
Gyroidina soldanii d'Orbigny										R											R	R				R	
Haplophragmoides sp.	R		S	S			C	S		S	S	S	C		C	C	S		S	S	C	C	C	C	C		
Heterostomella balconi Hedberg										R									R	R							
Hormosina ovelifornis Cushman										S	S	S									R		R	R	R	R	S
Lagena sp.						R				S	R				R			S	C	C							
Lenticulina sp.		R				S		R	S	R					C	S	S		S	C							
Marginulina glabra d'Orbigny										R										R							
Marginulina sublitus (Nuttall)																			R	R							
Marginulina wallacei Hedberg										R	R	S						C	S	C							
Miliolidae undif.					R		R	R		R					S		S		R	R		S					
Miogypsina sp.																	R										
Nodosaria longiscata d'Orbigny						R	R			R	S						R										
Nodosaria nuttalli Hedberg										C				R				R	R	S							
Nodosaria pariana Hedberg																		S	S	S						R	
Nodosaria raphanistrum (Linné) var. caribbeana Hedberg										R					R		R		R	R	R						
Nodosaria vertebralis (Batsch)										C	C							S	C	S							
Nonion belridgensis Barbat and Johnson				S	S	S	R			R	S	R			R		R		S	R	S	C				S	
Planularia venezuelana Hedberg										S	R			R				R	R	C							
Plectofrondicularia californica Cushman and Stewart										R	R																
Plectofrondicularia vaughani Cushman																											
Pseudoglandulina comatula (Cushman)				R						C									R	S							
Robulus calcar (Linné)		R			R					C	S	C							S	R					S		
Robulus clericii (Fornasini)		S	R	S	R			R	R	R			R					R	R	S							
Robulus sp.		S	S		C				S	S			R	S	S	S	S	S	C	C	S		R		S	R	
Rzehakina venezuelana Hedberg				R				R		S	R				R							S		S			
Saccammina sp.																					S		S		S		
Saracenaria senni Hedberg							R			S																	
Sigmoilina crinocoensis Hedberg															S		S										
Sigmoilina tenuis (Czjzek)										R										R							
Siphogenerina transversa Cushman					R		R			R		R							R								
Siphonina tenuicarinata Cushman							R			S		R		R				R	S	C							
Sphaeroidina variabilis Reuss							R			C	S			R		R		S	A	C							
Textularia grenadana Hedberg							R			S	S	S															
Textularia mexicana Cushman										S	C	S		S				S	C	C							
Textularia sp.								R	R							R			S	C	R	R	R				
Textulariella barretti (J. and P.)														R				C	R	S					R		
Trochammina cf. conglobata Brady		S	S	C	S	S			C	S	R	C	R	R								S		C	C	C	
Uvigerina carapitana Hedberg																		C		S							
Uvigerina pygmaea d'Orbigny var. sapygna Hedberg			R	R						S	C	C		R		R	R	S	S	C		R				S	
Valvulineria venezuelana Hedberg													R	R	R			C	C	C							
Verneuilina sp.		S		S	S	C						S	S			S						S		R		R	R

and I wish to express to H. G. Schenck of that university my appreciation for constant encouragement and helpful criticism and suggestions throughout the course of the work.

I am particularly indebted to J. A. Cushman for assistance in the work on the Carapita Foraminifera. I spent two weeks in checking identifications at the Cushman Laboratory in Sharon, Mass., and have also had the benefit of Doctor Cushman's invaluable criticism and suggestions during the preparation of the manuscript. Through his courtesy drawings of the Carapita Foraminifera were made by Patricia Edwards, illustrator at the Cushman Laboratory, to whom much credit is due for skillful and painstaking work.

It is a pleasure to acknowledge the friendly coöperation of many other institutions and individuals in making available foraminiferal material for comparison. Through the efforts of Doctor Schenck, foraminiferal samples (in many cases topotype material) were obtained from California, Colombia, Costa Rica, Mexico, Bonaire, and many classic localities in Europe. R. M. Kleinpell furnished specimens from California and information on the stage classification of the California section. My collections from Trinidad were supplemented by material supplied by P. W. Jarvis and H. Naegelli; and H. Kugler and E. Lehner furnished important information on the stratigraphic position of samples from that island. D. K. Palmer supplied an excellent set of samples from Cuba, and J. B. Garrett furnished samples from the Gulf Coast of the United States and interesting information concerning the succession of microfaunas in that region. Additional type foraminiferal material from Colombia, Cuba, and Ecuador was made available through the courtesy of I. P. Tolmachoff of the Carnegie Institution of Pittsburgh; G. D. Harris of the Paleontological Research Institution of Ithaca, N. Y.; and members of the paleontological staff at Columbia University.

DESCRIPTION OF SPECIES

Genus BATHYSIPHON Sars

BATHYSIPHON CARAPITANUS Hedberg, n. sp.
Plate 90, figure 1

Samples throughout the Carapita formation frequently show fragments of an elongate, tubelike, finely arenaceous form which is probably referable to *Bathysiphon*. The tubes are open at both ends and show no chamber divisions, although weak annular folds or constrictions are characteristic. The walls are heavy but finely arenaceous. Specimens are always flattened due to collapse of the wall material and may even show a slight depression along the axial line. Holotype from sample E-4023. Length, 2.25 mm.; width, 0.55 mm. Cushman Coll., no. 23,570.

Remarks.—This form, which is easily recognized and is preserved where other Foraminifera are lost or unrecognizable, is quite distinctive of the Carapita formation. It is similar to *Bathysiphon* sp. of Cushman and Hobson (1935, p. 55) from the San Lorenzo formation of California. Another more slender species of *Bathysiphon* is less common in the Carapita formation.

Genus SACCAMMINA Sars

A number of samples in the upper zone of the formation carry a form belonging to this or closely related genera.

Genus HORMOSINA Brady

HORMOSINA OVALIFORMIS Cushman
Plate 90, figure 2

Hormosina ovaliformis CUSMAN, *1910*, U. S. Nat. Mus., Proc., vol. 38, p. 438, text figs. Recent. Phillipine Islands. *1920*, U. S. Nat. Mus., Bull. 104, pt. 2, p. 31, pl. 6, fig. 5. Recent. Gulf of Mexico, Caribbean Sea.

[?]*Hormosina globulifera* Brady, NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 71. Middle Tertiary, Trinidad.

Length of figured specimen, 0.85 mm. Cushman Coll., no. 23,571.

Genus Ammodiscus Reuss

Ammodiscus incertus (d'Orbigny)

Operculina incerta d'Orbigny, *1839*, in De La Sagra's Hist. phys., pol., et nat. de l'Ile de Cuba, p. 49, pl. 6, figs. 16, 17.

Ammodiscus incertus (d'Orbigny), Guppy, *1904*, Geol. Mag., dec., 5, vol. 1, p. 195. Boring at Sangre Grande, Trinidad.—Cushman, *1918*, U. S. Nat. Mus., Bull. 104, pt. 1, p. 95, pl. 39, figs. 1–8. Recent. Gulf of Mexico, Caribbean Sea, etc.—Cole, *1927*, Bull. Am. Paleontology, vol. 14, no. 51, p. 10, pl. 4, fig. 17. Guayabal formation, Mexico.—Nuttall, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 70, Eocene to Miocene, Trinidad.—Cole, *1928*, Bull. Am. Paleontology, vol. 14, no. 53, p. 5. Chapapote formation of Mexico.—Nuttall, *1932*, Jour. Paleontology, vol. 6, p. 5. Alazan formation of Mexico; *1935*, Jour. Paleontology, vol. 9, p. 122. Pauji shale of Venezuela.

This well-known species occurs in a number of samples from Quebrada Carapita. Specimens frequently show an elliptical form due to distortion after deposition of the inclosing sediment.

Ammodiscus parianus Hedberg, n. sp.
Plate 90, figure 3

Test small, thin, planispiral; consisting of about six rather indistinct whorls; glassy appearance due to excess of cement over granular particles. The coiled tubular space is frequently filled with reddish material. Average diameter: 0.30 to 0.35 mm. Holotype from Sample E-4035. Cushman Coll., no. 23,572.

Remarks.—This species is more common than *A. incertus* in the Carapita formation. It is consistently smaller and the whorls are less distinct.

Genus Haplophragmoides Cushman

Three or four forms belonging to this genus are fairly common in the Carapita formation. They are quite variable and usually distorted. The characters are not sufficiently distinctive to warrant the setting up of new species and it is not possible to assign them with assurance to any described species.

Genus Ammobaculites Cushman

An unnamed species is fairly common in the upper part of the Carapita formation.

Genus Cyclammina Brady

Cyclammina cancellata Brady

Cyclammina cancellata Brady, *1884*, Challenger Rept., Zoology, vol. 9, p. 351, pl. 37, figs. 8–16. Recent.—Nuttall, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 71, pl. 3, fig. 1. Eocene to Miocene, Trinidad; *1935*, Jour. Paleontology, vol. 9, p. 122. Pauji shale of Venezuela.

Cyclammina cancellata Brady var. *deformis* Guppy, *1904*, Geol. Mag., dec. 5, vol. 1, p. 195, pl. 9, fig. 3. Boring at Sangre Grande Trinidad.

This species, which is so abundant in the Tertiary of Trinidad, is only fairly common in the Carapita formation. Specimens commonly attain a size of 1.50 to 2.00 mm.

Genus Textularia Defrance

Textularia mexicana Cushman
Plate 90, figure 4

Textularia mexicana Cushman, *1922*, U. S. Nat. Mus., Bull. 104, pt. 3, p. 17, fig. 9. Recent. Gulf of Mexico; *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 79, pl. 12, fig. 4. Aguide, Venezuela.—Cushman and Barbat, *1932*, Cushman Lab. Foram. Research, Contr., vol. 8, p. 33, pl. 5, figs. 3 *a*, *b*. Temblor formation, California

[not]*Textularia mexicana* Cole, *1927*, Bull. Am Paleontology, vol. 14, no. 51, p. 11, pl. 5, fig. 3.

This striking species from the Gulf of Mexico and from the Miocene of California and western Venezuela is common in the middle part of the Carapita formation. In the specimens from eastern Venezuela the sutures are strongly elevated near the median line in the later part of the test. The peripheral margin is variably denticulate or smooth. There is much variation among individuals in shape, thickness, and number of chambers. In some specimens the increasing overlap of succeeding chambers along the median line is such that the test approaches a *Vulvulina*-like form. Dimensions of figured specimen: length, 0.70

mm.; width, 0.63 mm.; thickness, 0.23 mm. Cushman Coll., no. 23,573.

Remarks.—The form described by Galloway and Morrey (1929) from Manta, Ecuador, as *T. flabelliformis* Gümbel is similar to *T. mexicana*, although somewhat larger and thicker. It probably has varietal relationship. Nuttall's (1932) *T. dentimarginata* from the Alazan formation of Mexico is also very close to *T. mexicana*, and the differences in thickness and number of chambers seem to be within the limits of individual variation shown by the Carapita specimens.

TEXTULARIA GRENADANA Hedberg, n. sp.
Plate 90, figures 5*a*, *b*, 6

Test long, tapering; widest at or near the apertual end; rhomboid in end view. Periphery straight or gently bowed outward; slightly lobate at the outer margin of each chamber. Chambers numerous as many as 14 pairs; elongate, pointed at inner ends. Sutures fine, distinct. Wall thick, smooth, finely arenaceous; usually white. Holotype from Sample E-4022. Length, 0.92 mm.; maximum breadth, 0.40 mm. Cushman Coll., no. 23,574.

Remarks.—A characteristic and distinctive feature of the species is the presence of depressed longitudinal furrows on both sides of the test just within the lateral margins. This is doubtless a secondary feature due to collapse of the chamber walls after burial, yet it is so general as to constitute one of the readiest means of recognizing the species.

Genus VERNEUILINA d'Orbigny

Two species are fairly common but have not been identified. In the Quebrada Carapita section they are invariably so flattened and distorted that it does not seem desirable to figure and describe them here.

Genus GAUDRYINA d'Orbigny

GAUDRYINA (PSEUDOGAUDRYINA) JACKSONENSIS Cushman
Plate 90, figures 7*a*, *b*

Gaudryina jacksonensis CUSHMAN, *1926*, Cushman Lab. Foram. Research, Contr., vol. 2, p. 33, pl. 5, figs. 1*a*, *b*. Upper Eocene of South Carolina, Alabama, Mississippi; also Alazan formation of Mexico.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 7, pl. 2, fig. 5. Alazan formation of Mexico.—CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 9, pl. 2, figs. 4–6. Cooper marl, South Carolina; Ocala limestone, Alabama; Jackson formation, Mississippi.

[?]*Tritaxia schotburghi* PIJPERS, *1933*, Geog. geol. Mededeel., Phys.-Geol. Reeks, no. 8, p. 58, figs. 22–26. Upper Eocene of Bonaire, Dutch West Indies.

A few poorly preserved specimens from the middle part of the Carapita formation are assigned to this species. They are particularly close to Nuttall's specimens from the Alazan formation of Mexico, and, like these, show a relatively strong development of the triserial portion of the test which occupies half or more than half of its length. The triserial portion is much reduced in the type. The Carapita specimens are strongly ridged along the edges between the sides. Average length, 1.30 mm.; average thickness, 0.60 mm. Cushman Coll., no. 23,575.

Remarks.—Published descriptions of *G. jacksonensis* are all from Lower Tertiary strata, but the form is known to be present in the Miocene of western Venezuela and also in the lower Brasso beds of Trinidad. Pijper's drawings of his *Tritaxia schotburghi* from the upper Eocene of Bonaire suggest that it is closely related to *G. jacksonensis*, and examination of topotype material shows that mature specimens become biserial. *G. jacksonensis* falls within the new subgenus, *Pseudogaudryina*, recently created by Cushman (1936, p. 12).

Genus HETEROSTOMELLA Reuss

HETEROSTOMELLA (?) HALCONI
Hedberg, n. sp.
Plate 90, figures 9*a–c*

Initial third of test triserial and sharply triangular, changing abruptly to a biserial arrangment and a roughly quadrangular shape. Six to eight chambers in biserial portion. Aperture nearly terminal with a short neck and lip. Wall

finely arenaceous. Average length, 0.50 to 0.60 mm. Holotype from Sample E-4029, base of Cerro Halcon, on Quebrada Carapita. Cushman Coll., no. 23,578.

Remarks.—This species is questionably assigned to the genus *Heterostomella*. It resembles Nuttall's (1928) *Guadryina trinitatensis* from Trinidad but the aperture is different.

Genus CLAVULINA d'Orbigny

CLAVULINA CURTA Galloway and Morrey

Clavulina curta, GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 34, pl. 5, fig. 5. Manta, Ecuador.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 81, pl. 12, fig. 10. Aguide, Venezuela.

Specimens from the Carapita formation are smaller than those of Galloway and Morrey from Ecuador and the uniserial portion is relatively shorter. The change to uniserial arrangement of chambers is abrupt.

Genus DOROTHIA Plummer

DOROTHIA NUTTALLI Cushman
Plate 90, figures 8*a*, *b*

Gaudryina asiphonia (Andreae), NUTTALL, *1932*, Jour Paleontology, vol. 6, p. 7, pl. 2, fig. 3. Alazan formation of Mexcio.
Dorothia nuttalli CUSHMAN, *1936*, Cushman Lab. Foram. Research, Special Pub. 6, p. 29, pl. 4, figs. 12*a*, *b*.
[not] *Gaudryina siphonella* var. *asiphonia* ANDREAE, *1884*, Abh. Geol. Specialkarte Elsass-Lothr., vol. 2, p. 200, pl. 7, fig. 7.

Cushman considers this species a *Dorothia* rather than a *Gaudryina*, but the initial multiserial arrangement is difficult to discern in most specimens. Length of figured specimen 0.50 mm. Cushman Coll., no. 23,576.

DOROTHIA ASIPHONIA (Andreae)
Plate 90, figure 10

Gaudryina siphonella var. *asiphonia* ANDREAE, *1884*, Abh. Geol. Specialkarte Elsass-Lothr., vol. 2, p. 200, pl. 7, fig. 7. Oligocene of Alsace.
[not] *Gaudryina asiphonia* (Andreae), NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 7, pl. 2, fig. 3.
[not] *Gaudryina asiphonia* (Andreae), HADLEY, *1934*, Bull. Am. Paleontology, vol. 20, no. 70A, p. 8, pl. 1, fig. 6.

The Venezuelan form compares very closely with topotypes of Andreae's species seen in the Cushman Laboratory. The short rounded multiserial initial portion of the test is followed by a relatively long biserial portion in which the length of the chambers tends to become more and more nearly parallel to the axis of the test. The wall is finely arenaceous; usually reddish in color. Length, 0.60 mm. to more than 1.00 mm. Figured specimen: Cushman Coll., no. 23,579.

Genus TEXTULARIELLA Cushman

TEXTULARIELLA BARRETTII (Jones and Parker)
Plate 90, figure 11

Textularia barrettii JONES and PARKER, *1863*, Rept. Brit. Assoc., Newcastle Meeting pp. 80, 105.—BRADY, *1884*, Challenger Rept., Zoology, vol. 9, p. 367, pl. 44, figs. 6–8. Recent oceans.—CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, p. 31, pl. 6, figs. 5–7. Bowden marl, Jamaica.—CUSHMAN, *1922*, U. S. Nat. Mus., Bull. 104, pt. 3, p. 20, pl. 3, figs. 3–6. Recent, West Indian region.
Textularia trochus d'Orbigny, GUPPY, *1904*, Geol. Mag., dec. 5, vol. 1, p. 196, pl. 9, fig. 8. Boring at Sangre Grande, Trinidad.
Textulariella barrettii (Jones and Parker), CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 24, pl. 5, fig. 3. —CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 11, pl. 2, figs. 2*a*, *b*. Cooper marl (upper Eocene), South Carolina.
[?] *Textulariella barrettii* (Jones and Parker)?, PIJPERS, *1933*, Geog. geol. Mededeel, Phys. Geol. Reeks 8, p. 57, figs. 11–13. Upper Eocene of Bonaire, Dutch West Indies.

This broadly defined species, which is living at the present time in the West Indian region, is also known from Miocene and even Eocene deposits. The Carapita specimens are smaller than the typical, averaging about 0.60 mm. in length. Figured specimen, Cushman Coll., no. 23,580.

Genus RZEHAKINA Cushman

RZEHAKINA VENEZUELANA Hedberg, n. sp.
Plate 90, figure 12

Elliptical, planispiral, compressed; each chamber forming half a coil. About 9 slender chambers, attenuated at both ends. Initial chambers usually raised. Wall clear, siliceous. Holotype from Sample E-4021. Length, 0.40 mm.; thickness, 0.07 mm. Cushman Coll., no. 23,581.

Remarks.—This Tertiary *Rzehakina* is quite different from *R. epigona* and its varieties from the Cretaceous. It is smaller, more compressed, and has more numerous and more clearly defined chambers. It is very rare in the Carapita formation.

Family MILIOLIDAE

This family is very poorly represented in the Carapita formation. Several poorly preserved specimens of *Quinqueloculina* and *Triloculina* have been noticed but are scarcely worthy of description. Two species of *Sigmoilina* are present but rare.

Genus SIGMOILINA Schlumberger

SIGMOILINA TENUIS (Czjzek)

Quinqueloculina tenuis CZJZEK, *1847*, Haidinger's Naturwiss. Abh., vol. 2, p. 149, pl. 13, figs. 31–34. Miocene of Vienna Basin.

Sigmoilina tenuis (Czjzek), CUSHMAN, *1918*, U. S. Nat. Mus., Bull. 103, p. 81, pl. 31, figs. 4*a–c*. Gatun formation of Panama.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 81, pl. 12, figs. 12–14. Aguide, Venezuela; Manta, Ecuador.—CUSHMAN, *1930*, Florida Geol. Survey, Bull. 4, p. 22, pl. 2, figs. 8*a–c*. Choctawhatchee formation of Florida.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 9, pl. 1, fig. 4. Alazan formation of Mexico.

This is a very variable species. Carapita formation specimens are close to topotypes seen in the Cushman Laboratory.

SIGMOILINA ORINOCOENSIS Hedberg, n. sp.
Plate 90, figures 13*a*, *b*

Test small, stout, sigmoid in cross section. Chambers few; sides covered with fine arenaceous matter so that only last two chambers are distinct. Periphery broadly rounded to truncate. Last chamber projecting at apertural end. Aperture elliptical with a blunt tooth. Holotype from Sample E-4026. Length, 0.52 mm.; width, 0.36 mm.; thickness, 0.25 mm. Cushman Coll., no. 23,582.

Genus TROCHAMMINA Parker and Jones

TROCHAMMINA cf. CONGLOBATA Brady

Trochammina conglobata BRADY, *1884*, Challenger Rept., Zoology, vol. 9, p. 341, pl. 40, figs. 8, 9. Recent off West Indies and coast of South America.—NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 71. "Marl and Green Clay" of Trinidad.

Forms which are tentatively assigned to this species are common in the lower and upper zones of the Carapita formation.

Genus ROBULUS Montfort

ROBULUS CLERICII (Fornasini)

Cristellaria clericii FORNASINI, *1895*, "Christellaria clericii, n. sp." Bologna, text figure. [fide Cushman]. Neogene of Italy.—CHAPMAN, *1898*, Geol. Soc. London, Quart. Jour., vol. 54, p. 554, [list.] Globigerina marl, Bissex Hill, Barbados.—NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 87, pl. 5, fig. 10. Middle Tertiary of Trinidad.

Robulus clericii (Fornasini), CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 84, pl. 12, figs. 16, 17. Aguide, Venezuela; Manta, Ecuador.—HOWE and WALLACE, *1932*, Louisiana Geol. Survey, Bull. 2, p. 38, pl. 15, fig. 3. Jackson Eocene of Louisiana.

Senn (1935, p. 76) has remarked that this species is characteristic of the Agua Salada clays of eastern Falcon, Venezuela, and that it is limited to the Miocene in Morocco.

ROBULUS CALCAR (Linné)

Nautilus calcar LINNÉ, *1767*, Syst. Nat., 12th ed., p. 1162, no. 272.

Cristellaria calcar (Linné) [part], BRADY, *1884*, Challenger Rept., Zoology, vol. 9, p. 551, pl. 70, figs. 9–12, [not figs. 13–15.] Recent, West Indies.—CUSHMAN, *1923*, U. S. Nat. Mus., Bull. 104, pt. 4, p. 115, pl. 30, fig. 7. pl. 31, figs. 4, 5. Recent. Florida

coast, Gulf of Mexico, Caribbean Sea.—NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 86, pl. 5, fig. 8. Middle Tertiary of Trinidad.

Robulus calcar (Linné), GALLOWAY and MOREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 20, pl. 2, fig. 10. Manta, Ecuador.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 84, pl. 12, fig. 18. Aguide, Venezuela; Manta, Ecuador; Trinidad.—[?] CUSHMAN and JARVIS, *1930*, Jour. Paleontology, vol. 4, p. 358, pl. 32, fig. 9. Buff Bay, Jamaica.

Lenticulina calcar (Linné), HADLEY, *1934*, Bull. Am. Paleontology, vol. 20, no. 70A, p. 11. Oligocene of Cuba.

Genus LENTICULINA Lamarck

Several species of *Lenticulina* or *Robulus* other than those mentioned occur in the Carapita formation. Two forms, one of which is similar to the usual interpretation of *L. rotulata* (Lamarck) and one which is close to *L. vicksburgensis* (Cushman), are the most common.

Genus PLANULARIA Defrance

PLANULARIA VENEZUELANA Hedberg, n. sp.

Plate 90, figures 14*a*, *b*

Test compressed laterally; close-coiled; 2 to 3 whorls. Periphery sharply truncate with a broad but very delicate median keel. Chambers distinctly inflated; gradually increasing in size; 6 in last whorl. Sutures distinct, clear glassy; strongly curved and increasing in width toward the periphery where they merge with the equally clear and glassy peripheral margin. Aperture radiate at the upper angle of the chamber, and connected with the chamber cavity by a tube which is clearly visible through the hyaline front wall of the chamber. These apertural tubes may also be seen passing through the sutures between earlier chambers. Holotype from Sample E-4023. Length, 0.48 mm.; width, 0.39 mm.; thickness, 0.15 mm. Cushman Coll., no. 23,583.

Remarks.—This species somewhat resembles *P. clara* Cushman and Jarvis (1929) from the "Sagrina Beds" of Trinidad, but has only a single median keel, inflated chambers, more strongly curved sutures, clearly visible apertural stolons, and a more nearly circular outline. It is also known from the Agua Salada clays of western Venezuela.

Genus MARGINULINA d'Orbigny

MARGINULINA SUBLITUUS (Nuttall)

Cristellaria sublituus NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 11, pl. 1, figs. 13, 14. Alazan formation of Mexico.

MARGINULINA GLABRA d'Orbigny

Marginulina glabra D'ORBIGNY, *1826*, Annals sci. nat., vol. 7, p. 259, no. 6, Modele no. 55.—BRADY, *1884*, Challenger Rept., Zoology, vol. 9, p. 527, pl. 65, figs. 5, 6. Recent oceans.—NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 91. Middle Tertiary of Trinidad.—NUTTALL, *1930*, Jour. Paleontology, vol. 4, p. 283. Aragon formation of Mexico.

MARGINULINA WALLACEI Hedberg, n. sp.

Plate 90, figures 15–17

Cristellaria subaculeata var. *glabrata* Cushman, NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 90, pl. 6, figs. 1, 5. Upper Eocene to Miocene of Trinidad.

[not] *Cristellaria subaculeata* var. *glabrata* CUSHMAN, *1923*, U. S. Nat. Mus., Bull. 104, p. 124, pl. 32, fig. 4; pl. 33, figs. 2, 3; pl. 34, fig. 3. Recent, Gulf of Mexcio.

Greater part of test close coiled; last chambers becoming uncoiled. Strongly biconvex. Periphery weakly keeled or with spines; slightly lobulate in later part of test. Seven to nine moderately inflated chambers; early ones rather indistinct. Sutures heavily beaded. Beads tend to become elongated in direction of chamber growth, especially near periphery and in later part of test. The ornamentation is quite variable and in some specimens the beads are prolonged into ribs which even cross the sutures. Wall thick. Aperture terminal, radiate (occasionally slightly robuline) on a projecting neck. No distinct apertural face on last chamber of fully developed specimens. Holotype from Sample E-4021. Length, 0.97 mm.; thickness, 0.50 mm. Cushman Coll., no. 23,584.

Remarks.—This species is named in honor of William T. Wallace, vice-president of the Venezuela Gulf Oil Com-

pany, through courtesy of whom this paper is published. The generic designation is somewhat questionable, as the species lies on the border line between *Lenticulina*, *Marginulina*, and *Robulus*. There is a close resemblance to *Robulus subaculeata* var. *glabrata* Cushman (1929, 1918–31) from the Gulf of Mexico and also from Aguide, Venezuela. However, that species shows a stronger tendency toward a robuline aperture, is usually somewhat more compressed, is more strongly keeled, and maintains a distinctly marked-off apertural face even in the later chambers.

Genus DENTALINA d'Orbigny

DENTALINA ADOLPHINA d'Orbigny

Dentalina adolphina D'ORBIGNY, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 51, pl. 2, figs. 18–20. Miocene of Vienna Basin.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 86, pl. 13, figs. 3, 4. Aguide, Venezuela; Manta, Ecuador; Trinidad.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 14. Alazan formation of Mexico.—HADLEY, *1934*, Bull. Am. Paleontology, vol. 20, no. 70A, p. 10. Oligocene (upper?) of Cuba.

Dentalina cf. *D. adolphina* d'Orbigny, CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 21, pl. 8, figs. 11, 12. Upper Eocene of South Carolina.

Nodosaria adolphina (d'Orbigny), GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology vol. 15, no. 55, p. 16, pl. 2, fig. 1. Manta, Ecuador.—[?] NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 125. Pauji shale of Venezuela.

Nodosaria lepidula Schwager, GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 17, pl. 2, fig. 2. Manta, Ecuador. This species, which lies on the border line between *Nodosaria* and *Dentalina*, ranges from upper Eocene to Miocene in the Caribbean region.

Genus NODOSARIA Lamarck

NODOSARIA RAPHANISTRUM (Linné) var. CARIBBEANA Hedberg, n. var.

Plate 91, figure 1

[?] *Nodosaria raphanistrum* (Linné), GUPPY, *1904*, Geol. Mag., dec. 5, vol. 1, p. 196, pl. 9, fig. 9. Boring at Sangre Grande, Trinidad.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 16, pl. 3, fig. 10. Alazan formation of Mexico.

[?] *Nodosaria* sp. NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 84, pl. 4, fig. 22. Upper Eocene to Miocene of Trinidad.

Due to the uncertainty regarding the exact characters possessed by Linné's species, it seems desirable to make a variety of the form common in the Tertiary of the Caribbean region. It is large and thick-walled and carries 12 to 16 strong, high, plate-like ribs which cross the sutures with only slight diminution of strength. The test is markedly constricted at the sutures, giving the chambers a subglobular shape. Specimens reach a length of more than 5 mm. Holotype of variety from Sample E-4023. Cushman Coll., no. 23,586.

NODOSARIA VERTEBRALIS (Batsch)

Plate 91, figure 2

Nautilus (*Orthoceras*) *vertebralis* BATSCH, *1791*, Conchylien des Seesands, pt. 3, no. 6, pl. 2, figs. 6*a*, *b* [fide Cushman]. Recent, Adriatic Sea.

Nodosaria vertebralis (Batsch), FLINT, *1899*, U. S. Nat. Mus., Rept. for 1897, p. 312, pl. 57, fig. 5. Recent, Gulf of Mexico.—CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, p. 35, pl. 7, figs. 3–5. Bowden marl of Jamaica.—CUSHMAN, *1923*, U. S. Geol. Survey, Prof. Paper 133, p. 27, pl. 4, fig. 1. Vicksburg group of Mississippi.—[?] PLUMMER, *1926*, Univ. Texas, Bull. 2644, p. 88, pl. 5, fig. 10. Midway stage of Texas.—GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 14, pl. 1, fig. 10. Manta, Ecuador.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 86. Aguide, Venezuela; Manta, Ecuador.—NUTTALL, *1930*, Jour. Paleontology, vol. 4, p. 283. Aragon formation of Mexico.—CUSHMAN and JARVIS, *1930*, Jour. Paleontology, vol. 4, p. 360. Buff Bay, Jamaica.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 15, pl. 3, fig. 9. Alazan formation of Mexico.

This species ranges from Eocene to Recent in the Caribbean region. Length of figured specimen, 2.70 mm. Cushman Coll., no. 23,587.

NODOSARIA LONGISCATA d'Orbigny

Plate 91, figures 3, 4

Nodosaria longiscata D'ORIBIGNY, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 32, pl. 1, figs. 10–12. Miocene of Vienna Basin.—NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 81, pl. 4, fig. 13. Upper

Eocene to Miocene of Trinidad.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 86, pl. 12, figs. 25, 26. Aguide, Venezuela.—[?] NUTTALL, *1930*, Jour. Paleontology, vol. 4, p. 283. Aragon formation of Mexico.—CUSHMAN and JARVIS, *1930*, Jour. Paleontology, vol. 4, p. 359, pl. 32, figs. 15, 16. Buff Bay, Jamaica. —[?]NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 15. Alazan formation of Mexico. —[?]CUSHMAN, *1932*, Florida Geol. Survey, Bull. 9, p. 62. Shoal River formation of Florida.—[?] BARBAT and VON ESTORFF, *1933*, Jour. Paleontology, vol. 7, p. 169. Vaqueros formation of California.—[?] NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 125. Pauji shale of Venezuela.

Nodosaria arundinea Schwager, GUPPY, *1904*, Geol. Mag., dec. 5, vol. 1, pl. 8, figs. 14, 15. "Naparima Oceanics" of Trinidad.—GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 16, pl. 1, fig. 15. Manta, Ecuador.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, pl. 13, figs. 1, 2. Manta, Ecuador.

[not] *Nodosaria longiscata* d'Orbigny, COLE and GILLESPIE, *1930*, Bull. Am. Paleontology, vol. 15, no. 57B, p. 8, pl. 3, fig. 9; pl. 4, fig. 1. Meson formation of Mexico.

[not] *Nodosaria longiscata* d'Orbigny, COLE and PONTON, *1930*, Florida Geol. Survey, Bull. 5, p. 33, pl. 6, fig. 4. Marianna limestone of Florida.

A long delicate reed-like *Nodosaria*, with slender tubular chambers divided by slightly but abruptly constricted sutures, is widely known in the Tertiary of tropical America. The chambers are frequently more than ten times as long as their diameter. Specimens are rarely found intact. This form has been variously assigned to *N. longiscata* and *N. arundinea*. Nuttall (1928) united the two and Cushman (1929) remarks that "the two species are very close, especially when a long series from the Vienna Basin is available for comparison." There seems to be little basis for distinguishing the two, and since d'Orbigny's species has priority it is accepted here. Figured specimens, Cushman Coll., no. 23,588.

NODOSARIA PARIANA Hedberg, n. sp.
Plate 91, figure 5

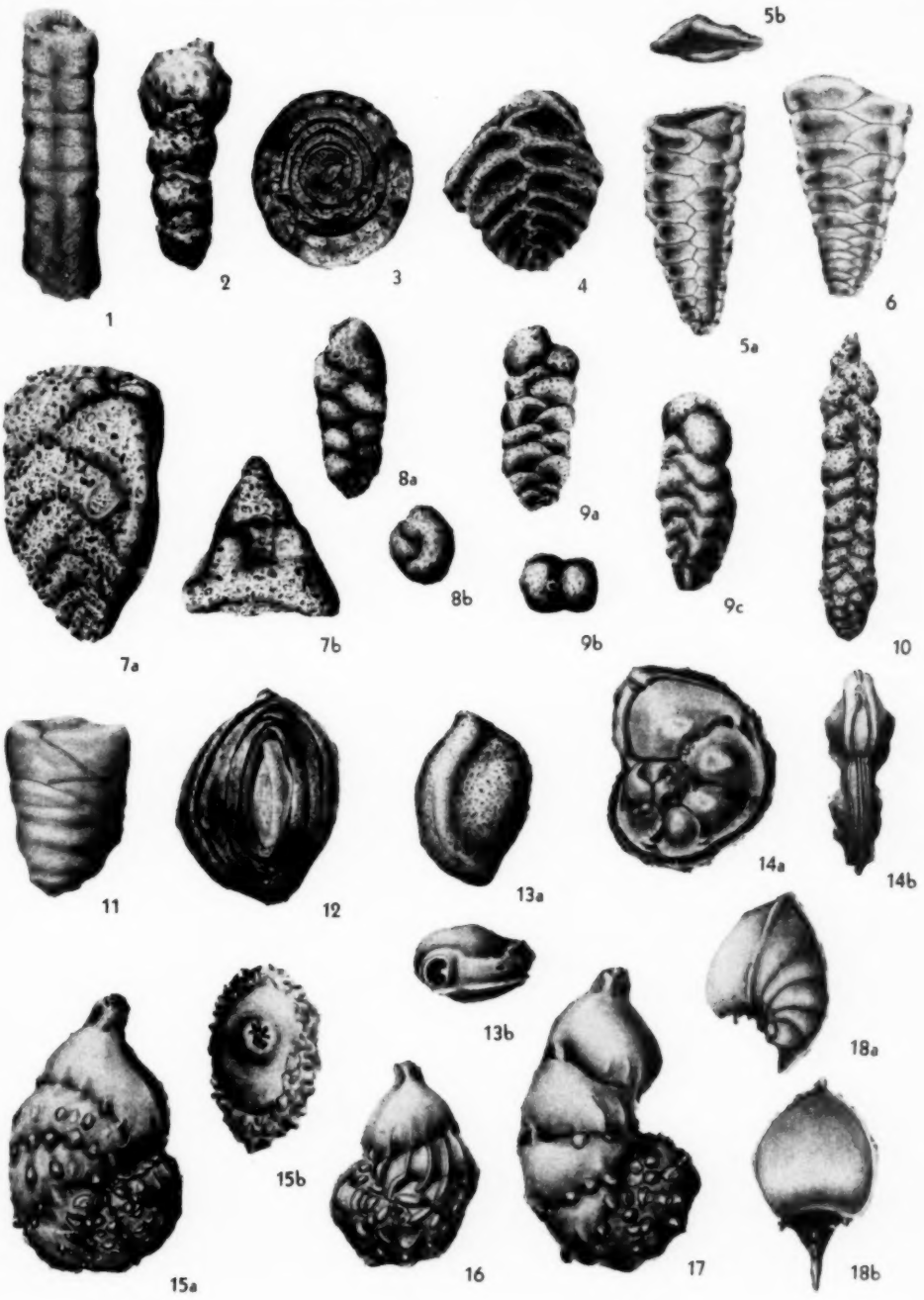
[?] *Nodosaria longiscata* d'Orbigny, GUPPY, *1904*, Geol. Mag., dec. 5, vol. 1, pl. 8, figs. 12, 13. "Naparima Oceanics" of Trinidad.

[not] *Nodosaria longiscata* d'Orbigny, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 32, pl. 1, figs. 10–12.—COLE and PONTON, *1930*, Florida Geol. Survey, Bull. 5, p. 33, pl. 6, fig. 4. Marianna limestone of Florida.

This is a larger stouter species than *N. longiscata*, although belonging to the same group of *Nodosaria* with elongate chambers. It consists of an initial bulb-shaped chamber with a terminal spine,

EXPLANATION OF PLATE 90

FIG. *1—Bathysiphon carapitanus* Hedberg, n. sp. Holotype, ×30. (p. 665)
2—Hormosina ovaliformis Cushman, ×50. (p. 665)
3—Ammodiscus parianus Hedberg, n. sp. Holotype, ×90. (p. 666)
4—Textularia mexicana Cushman, ×50. (p. 666)
5a, b, 6—Textularia grenadana Hedberg, n. sp. *5a*, Front view; *5b*, apertural view, holotype, (×50). *6*, Paratype, ×70. (p. 667)
7a, b—Gaudryina (Pseudogaudryina) jacksonensis Cushman, ×50. *a*, Front view; *b*, apertural view. (p. 667)
8a, b—Dorothia nuttalli Cushman. *a*, Front view, ×50; *b*, apertural view, ×60. (p. 668)
9a–c—Heterostomella (?) *halconi* Hedberg, n. sp. Holotype, ×65; *a*, front view; *b*, apertural view; *c*, side view. (p. 667)
10—Dorothia asiphonia (Andreae), ×50. (p. 668)
11—Textulariella barrettii (Jones and Parker), ×50. (p. 668)
12—Rzehakina venezuelana Hedberg, n. sp. Holotype, ×120. (p. 669)
13a, b—Sigmoilina orinocoensis Hedberg, n. sp. Holotype, ×65. *a*, Front view; *b*, apertural view. (p. 669)
14a, b—Planularia venezuelana Hedberg, n. sp. Holotype, ×90. *a*, Side view; *b*, apertural view. (p. 670)
15–17—Marginulina wallacei Hedberg, n. sp. *15*, Holotype, ×60; *a*, side view; *b*, apertural view. *16*, Paratype, ×50. *17*, Paratype, ×50. (p. 670)
18a, b—Saracenaria senni Hedberg, n. sp. Holotype; *a*, side view, ×80; *b*, apertural face, ×90. (p. 674)



Hedberg, Middle Tertiary Foraminifera

UNIV. OF MICH.

followed by long, tubular, but slightly inflated chambers. The length of each is usually no more than two or three times its diameter, at least in the early chambers. Holotype from Sample E-4032. Length, 0.65 mm. Cushman Coll., no. 23,589.

Remarks.—This species is also represented in western Venezuela, in the Alazan formation of Mexico, and in the upper Eocene sediments of Bonaire.

NODOSARIA NUTTALLI Hedberg, n. sp.
Plate 91, figure 6

Nodosaria aff. *carinata* (Neugeboren), NUTTALL, *1932*, Jour Paleontology, vol. 6, p. 16, pl. 3, fig. 11. Alazan formation of Mexico.

This species usually carries six platelike ribs which extend from the slightly bulbous initial end through the length of the test. The chambers are elongate, inflated in the central portion and gently constricted at the sutures, and are reflected in a slight sinuosity in the profile of the longitudinal costae. The test is nearly straight but the costae are usually twisted. The holotype is from Sample E-4032. Length, 0.70 mm.; maximum diameter (broken specimen), 0.10 mm. Cushman Coll., no. 23,590.

Remarks.—The Carapita specimens are identical with those from the Alazan formation which Nuttall has compared with *Nodosaria carinata*. They also resemble *Nodosaria acuminata* Hantken and *Dentalina elegantissima* Hadley. The form is present in upper Eocene material from Bonaire, and it may actually be Pijpers' (1933) *Nodosaria rutteni* although this species is stated to have only five costae.

Genus PSEUDOGLANDULINA Cushman

PSEUDOGLANDULINA COMATULA (Cushman)
Plate 91, figures 9, 10

Nodosaria comata Batsch, BRADY, *1884*, Challenger Rept., Zoology, vol. 9, p. 509, pl. 64, figs. 1–5. Recent, West Indies.

[not] *Nautilus* (*Orthoceras*) *comatus* Batsch, *1791*, Conchyl. des. Seesandes, p. 2, pl. 1, fig. 2 [fide Cushman].

Nodosaria comatula CUSHMAN, *1923*, U. S. Nat. Mus., Bull. 104, p. 83, pl. 14, fig. 5. Recent, Gulf of Mexico.—NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 84, pl. 5, fig. 3. Middle Tertiary of Trinidad

Glandulina comata (Batsch), GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 13, pl. 1, figs. 7*a*, *b*. Manta, Ecuador.

Pseudoglandulina gallowayi CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 87, pl. 13, fig. 13. Manta, Ecuador. —CUSHMAN and HOBSON, *1935*, Cushman Lab. Foram. Research, Contr., vol. 11, p. 59, pl. 8, figs. 17*a*, *b*. San Lorenzo formation of California.

Pseudoglandulina comatula (Cushman), NUTTALL, *1932*, Jour Paleontology, vol. 6, p. 16. Alazan formation of Mexico.

Finely costate forms of *Pseudoglandulina* are widespread in Tertiary and younger sediments of tropical America. These vary principally in the number of costae, the degree of depression of the sutures, and the presence or lack of costae over the whole of the last chamber. Immature specimens also differ from adults in these same features. All of these forms are here included in the one species, although it is possible that varietal names may be employed to advantage for variations which may have stratigraphic or geographic significance.

Specimens from the Carapita formation usually show from 20 to 50 longitudinal costae, though in immature forms this number is somewhat reduced. The lateral profiles are either straight or slightly lobulate and the radiate aperture is surrounded by a bare whitened area in which costae are absent or are very weak. Both mature and immature specimens from the Carapita formation are figured. Cushman Coll., no. 23,591.

Remarks.—The Recent specimens from the Gulf of Mexico usually have 35 to 45 costae, according to Cushman, but one topotype was seen at the Cushman Laboratory with as few as 31 costae. The immature specimen figured by Galloway and Morrey from Ecuador has 25 costae. Cushman made a new species of this Ecuadoran form and comments that it commonly has from 18 to 24 costae. His figure is also of a young individual. In the State of Falcon, western Vene-

zuela, two varieties with distinct stratigraphic ranges are developed: a form similar to that of the Carapita formation, and a form with only about 12 costae. The specimen from the San Lorenzo formation of California which Cushman and Hobson figured as *P. gallowayi* shows 25 costae. It seems impossible consistently to separate the variously named forms given in the preceding synonymy and they are here lumped into one species.

Genus SARACENARIA Defrance

SARACENARIA SENNI Hedberg, n. sp.
Plate 90, figures 18*a*, *b*

Test small, early portion close coiled; chambers rapidly increasing in size and uncoiling. Uncoiled portion curved though chambers do not reach back to previous whorl. About seven chambers, of which the last two make up more than half the size of the test. Periphery distinctly keeled; inner angles of each chamber in the uncoiled portion bear stout spines of glassy material. Margin of chamber between spines is broadly concave; apertural face triangular, inflated. Sutures distinct, curved. Aperture radiate, usually with a slit extending into the apertural face. Peripheral keel frequently produced into a spine at the initial end. Holotype from Sample E-4023; length, 0.45 mm.; height of apertural face, 0.31 mm.; width of apertural face, 0.27 mm. Cushman Coll., no. 23,592.

Remarks.—This species is named in honor of Alfred Senn, who first called my attention to its stratigraphic value in western Venezuela. It is very close to *S. schencki* Cushman and Hobson (1935) but differs from that species in its smaller size and in the peculiar spine at the initial end. It belongs to the group of *S. italica* Defrance.

Genus LAGENA Walker and Jacobs

Specimens of this genus showing considerable individual variation are present in many samples.

Genus NONION Montfort

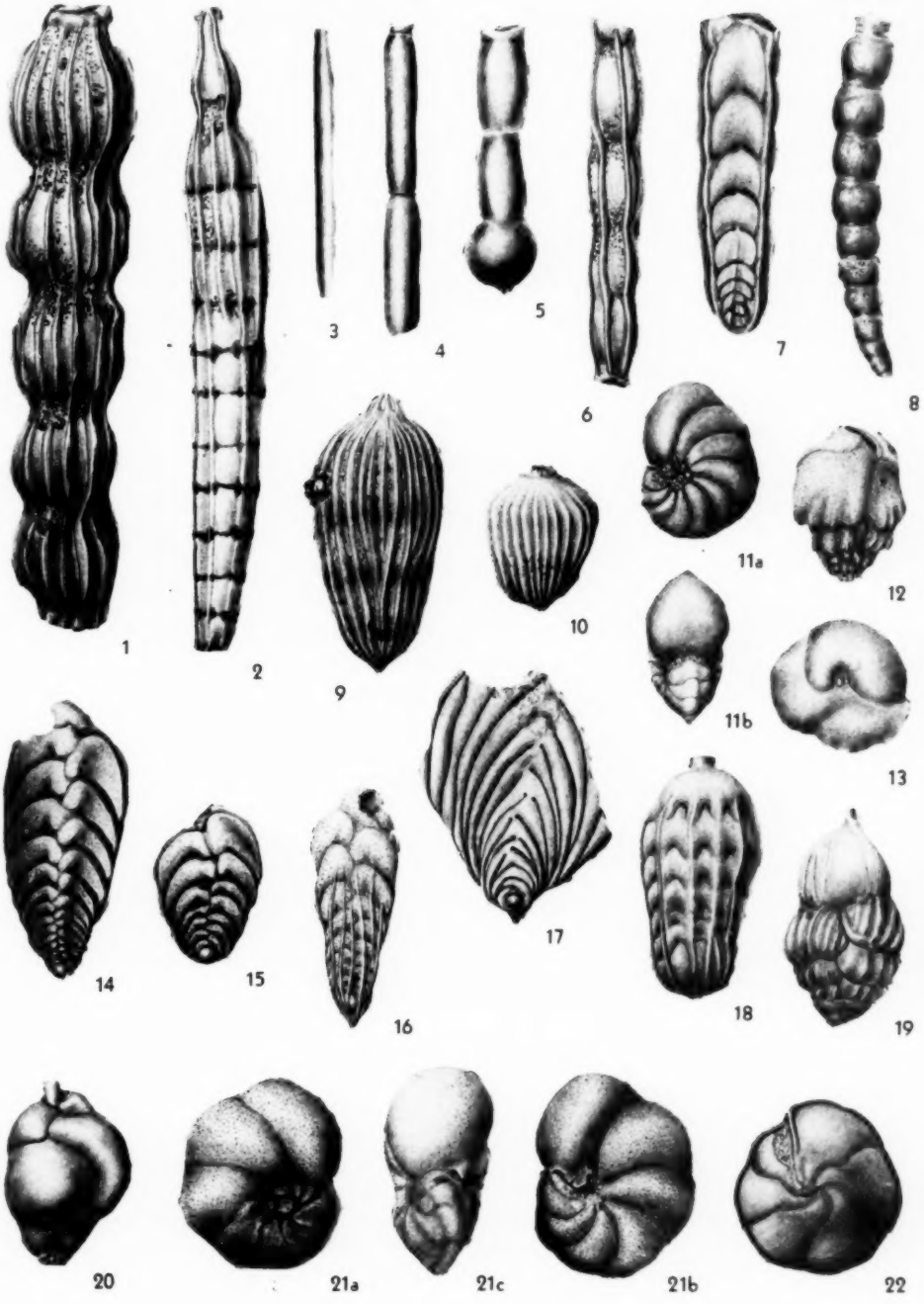
NONION BELRIDGENSIS Barbat and Johnson
Plate 91, figures 11*a*, *b*

Nonion belridgensis BARBAT and JOHNSON, *1934*, Jour. Paleontology, vol. 8, p. 11, pl. 1,

---

EXPLANATION OF PLATE 91

FIG. *1*—*Nodosaria raphanistrum* (Linné) var. *caribbeana* Hedberg, n. var. Holotype, ×33. (p. 671)
2—*Nodosaria vertebralis* (Batsch), ×50. (p. 671)
3, *4*—*Nodosaria longiscata* d'Orbigny, ×50. (p. 671)
5—*Nodosaria pariana* Hedberg, n. sp. Holotype, ×33. (p. 672)
6—*Nodosaria nuttalli* Hedberg, n. sp. Holotype, ×50. (p. 673)
7—*Plectofrondicularia californica* Cushman and Stewart, ×80. (p. 675)
8—*Ellipsonodosaria* (?) *verneuili* (d'Orbigny), ×33. (p. 678)
9, *10*—*Pseudoglandulina comatula* (Cushman), ×70. (p. 673)
11a, *b*—*Nonion belridgensis* Barbat and Johnson, ×80. *a*, Side view; *b*, front view. (p. 674)
12, *13*—*Bulimina bleeckeri* Hedberg, n. sp., ×90. *12*, Holotype; *13*, paratype. (p. 675)
14, *15*—*Bolivina alazanensis* Cushman var. *venezuelana* Hedberg, n. var., ×90. *14*, Holotype; *15*, paratype. (p. 676)
16—*Bolivina aenariensis* (Costa) var. *carapitana* Hedberg, n. var. Holotype, ×120. (p. 676)
17—*Plectofrondicularia vaughani* Cushman, ×80. (p. 675)
18—*Siphogenerina transversa* Cushman, ×65. (p. 677)
19—*Uvigerina pygmaea* d'Orbigny var. *capayana* Hedberg, n. var. Holotype, ×120. (p. 677)
20—*Uvigerina carapitana* Hedberg, n. sp. Holotype, ×90. (p. 677)
21a–c—*Valvulineria venezuelana* Hedberg, n. sp. Holotype, ×50. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view. (p. 678)
22—*Eponides umbonatus* (Reuss) var. *ecuadorensis* (Galloway and Morrey), ×120. (p. 679)



Hedberg, Middle Tertiary Foraminifera

UNIV. OF MICH.

figs. 8, 9. Reef Ridge shale (upper Miocene) of California.

Specimens from the Carapita formation agree with the holotype at Stanford University and with the original description (original figures poor). The holotype has 11 chambers in the last whorl, which agrees well with our specimens which have 9 to 12 chambers. Specimens from both regions are slightly asymmetrical and both have similarly shaped apertural faces. The sutures of the Venezuelan specimens are usually slightly more limbate and are frequently roughened near the umbilicus. Diameter of figured specimen, 0.38 mm. Cushman Coll., no. 23,593.

Remarks.—It is surprising to find that this form from the Carapita formation is indistinguishable from an upper Miocene *Nonion* from California. However, in Venezuela the same species also is found stratigraphically higher than the Carapita formation. The distinctions mentioned by Barbat and Johnson between this species and *N. pizarrense* Berry seem valid for the Carapita specimens also, after comparison with Peruvian material.

Genus PLECTOFRONDICULARIA Liebus

PLECTOFRONDICULARIA CALIFORNICA Cushman and Stewart

Plate 91, figure 7

Plectofrondicularia californica CUSHMAN and STEWART, *1926*, Cushman Lab. Foram. Research, Contr., vol. 2, p. 39, pl. 6, figs. 9–11. Lower Pliocene of California. —NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 92, pl. 6, fig. 9. Williamsville clay of Trinidad.—GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 36, pl. 5, fig. 11. Manta, Ecuador.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 90, pl. 13, figs. 18, 19. Aguide, Venezuela; Manta, Ecuador; Trinidad.

This species is rare and specimens are usually broken. It is another example of a Late Tertiary form from California which occurs much lower stratigraphically in the Caribbean region. Figured specimen, Cushman Coll., no. 23,594.

PLECTOFRONDICULARIA VAUGHANI Cushman

Plate 91, figure 17

Plectofrondicularia vaughani CUSHMAN, *1927*, Cushman Lab. Foram. Research, Contr., vol. 3, p. 112, pl. 23, fig. 3. Alazan formation of Mexico.—CUSHMAN, *1927*, Jour. Paleontology, vol. 1, pl. 25, fig. 11. Alazan formation of Mexico.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 92, pl. 13, figs. 21, 22. Aguide, Venezuela; Manta, Ecuador; Trinidad.—CUSHMAN and JARVIS, *1930*, Jour. Paleontology, vol. 4, p. 361, pl. 33, fig. 4. Buff Bay, Jamaica. —NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 19. Alazan formation of Mexico.—HADLEY, *1934*, Bull. Am. Paleontology, vol. 20, no 70A, p. 15, pl. 2, figs. 5, 6. Oligocene of Cuba.—CUSHMAN and HOBSON, *1935*, Cushman Lab. Foram. Research, Contr., vol. 11, p. 59, pl. 9, figs. 1*a*, *b*. San Lorenzo formation of California.

Plectofrondicularia cf. *P. vaughani* Cushman, CUSHMAN, *1935*, U. S. Geol. Survey, Prof. Paper 181, p. 34, pl. 12, figs. 8, 9. Cooper marl (upper Eocene), South Carolina.

Flabellina budensis Hantken, GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 11, pl. 1, fig. 3. Manta, Ecuador.

This widely known species has not yet been found on Quebrada Carapita, but is common in the Carapita formation 15 km. farther east on Rio Oregano. It is known to range from upper Eocene to middle Miocene in tropical America. Figured specimen, Cushman Coll., no. 23,595.

Genus BULIMINA d'Orbigny

BULIMINA BLEECKERI Hedberg, n. sp.

Plate 91, figures 12, 13

Variably top-shaped, with last three chambers usually making angles of at least 30 degrees with axis of test. Chambers numerous; as many as 18 visible on some specimens. Strongly overlapping; chambers of each whorl superimposed exactly above those of preceding whorl. Lower edges of chambers straight, at right angles to axis of test; each with 3 to 6 strong costae or crenulations which extend downward beyond the base of the chamber as blunt spines. On the last three chambers these costae are developed only near the lower margin, but are

probably more extensive over the earlier chambers though largely concealed by overlap. Sutures distinct. Aperture in a deep embayment of the last chamber margin, near where it overlaps the suture separating the second and third to the last chambers. Holotype from Sample E-4022. Length, 0.38 mm., maximum diameter, 0.28 mm. Cushman Coll., no. 23,596.

Remarks.—Miss Frances Parker, research assistant at the Cushman Laboratory, kindly examined specimens of this *Bulimina* and reports that it is undoubtedly a new species. It is probably the *B. inflata* Seguenza of a number of authors dealing with tropical American microfaunas, but is not Seguenza's species. It is close to *Bulimina* cf. *rinconensis* Cushman and Laiming, described from the lower member of the Los Sauces section (Kleinpell's Zemorrian stage, 1934) and from the San Lorenzo formation (Cushman and Hobson, 1935) in California. This species is named in honor of E. S. Bleecker, staff geologist in the New York office of the Venezuela Gulf Oil Company.

BULIMINA cf. INFLATA Seguenza

A number of specimens appear to be closely related to this species.

BULIMINA OVATA d'Orbigny?
BULIMINA PUPOIDES d'Orbigny?

A few specimens are doubtfully referred to these species of *Bulimina*. Both *B. ovata* and *B. pupoides* have been listed from the Caribbean region frequently, but in many cases the correctness of the identification is questionable.

Genus GLOBOBULIMINA Cushman

GLOBOBULIMINA cf. PACIFICA Cushman

This species is rare in the type section of the Carapita formation although common on the Rio Oregano. The delicate test is usually lost and specimens are preserved only as internal molds. *G. pacifica* has been reported frequently from Recent sediments in the Pacific Ocean. Its range is from Oligocene to Recent in California. It also occurs in the Miocene of Florida. In the Caribbean region it has been recorded from the Buff Bay Miocene of Jamaica (Cushman and Jarvis, 1930) and its presence is known in the Oligocene of western Venezuela, the Miocene of Trinidad, and the upper Eocene of Bonaire.

Genus BOLIVINA d'Orbigny

BOLIVINA ALAZANENSIS Cushman var. VENEZUELANA Hedberg, n. var.
Plate 91, figures 14, 15

This is one of the most common and distinctive species of the Carapita formation. It is clearly related to the Mexican Oligocene species, and, like it, shows much individual variation. The Venezuelan variety is somewhat thicker along the axis, thus giving a more rhomboidal appearance in end view, and the chambers are in general more sharply lobed at their inner extremities. It is very similar to the *Bolivina* sp. (?) recently described by Cushman and Hobson (1935) from the San Lorenzo formation of California. The holotype of the variety is from Sample E-4032. Length, 0.66 mm.; breadth, 0.30 mm.; thickness, 0.20 mm. Cushman Coll., no. 23,598.

BOLIVINA AENARIENSIS (Costa) var. CARAPITANA Hedberg, n. var.
Plate 91, figure 16

The species was first described by Costa from the Pliocene of Italy. Venezuelan specimens were compared with material from Siena at the Cushman Laboratory. They are somewhat larger, less sharply constricted at the initial end, and have fewer costae than the Venezuelan specimens. However, Costa's illustrations show variations both in shape and number of costae and the Venezuelan specimens are here considered as belonging to a variety of his species. Specimens figured by Brady from the North Atlantic appear to be very close to those from Venezuela. The *B. aenariensis* of Cushman (1918), from the Gatun for-

mation of Panama, is a broader, less elongate form. Holotype of variety from Sample E-4036. Length, 0.40 mm.; breadth, 0.14 mm. Cushman Coll., no. 23,600.

Genus UVIGERINA d'Orbigny

UVIGERINA PYGMAEA d'Orbigny var. CAPAYANA Hedberg, n. var.
Plate 91, figure 19

This form resembles d'Orbigny's species, but is shorter and stouter. All chambers but the last are ornamented with strong vertical costae. The last chamber is smooth or only very faintly ribbed and on well-preserved specimens is seen to be finely spinose. The neck is moderately long; none of the specimens examined show evidence of a lip. Holotype from Sample E-4023. Length, 0.42 mm.; diameter, 0.18 mm. Cushman Coll., no. 23,601.

Remarks.—A great many species have been included under the name of *U. pygmaea*. Of those from tropical America, the Venezuelan variety most nearly resembles that described by Hadley (1934) from the upper Eocene of Cuba.

UVIGERINA CARAPITANA Hedberg, n. sp.
Plate 91, figure 20

Test small, stout, compact, rather bulbous; periphery smoothly rounded. Triserial, with about 3 to 4 whorls visible. Sutures distinct, depressed; chambers inflated, laterally lobed. Wall thick; generally smooth though some specimens show faint longitudinal striations in the early chambers. Neck tubular, terminal, in a depression near the indented margin of the last chamber; usually without a distinct lip although the neck is often slightly flaring. Holotype from Sample E-4032. Length, 0.42 mm.; diameter, 0.30 mm. Cushman Coll., no. 23,602.

Remarks.—This species falls within the general *Uvigerina canariensis* group. It is closely related to a variety of this species described by Cushman (1918) from the lower part of the Culebra formation of Panama. The Venezuelan form is smaller and stouter than the variety described by Nuttall (1932) from the lower Oligocene of Mexico but otherwise very similar. It is also very close to *U. hootsi* Cushman and Kleinpell (1934) from the Miocene of California, which, however, is less depressed around the apertural neck and has a flaring lip. Nuttall (1928) illustrates *U. pygmaea* var. from Trinidad, which may be the same as our species.

Genus SIPHOGENERINA Schlumberger

SIPHOGENERINA TRANSVERSA Cushman
Plate 91, figure 18

Siphogenerina raphanus (Parker and Jones) var. *transversus* CUSHMAN, *1918*, U. S. Nat. Mus., Bull. 103, p. 64, pl. 22, fig 8. Lower part of Culegra formation in dark clay of north Pedro Miguel locks, Panama Canal Zone.—CUSHMAN, *1926*, U. S. Nat. Mus., Proc., vol. 67, art. 25, p. 6, pl. 1, fig. 6. Culebra formation of Panama; Brasso formation of Trinidad.—NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 94, pl. 6, fig. 14. Upper Eocene to Miocene of Trinidad. Particularly common in Williamsville and Naparima clays.

Siphogenerina raphana (Parker and Jones) var. *transversa* Cushman, CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 95. Aguide, Venezuela.

Siphogenerina transversa Cushman, CUSHMAN and LAIMING, *1931*, Jour. Paleontology, vol. 5, p. 112, pl. 12, fig. 13. Los Sauces Creek section of California (Saucesian and upper Zemorrian stages of Kleinpell).—CUSHMAN and PARKER, *1931*, Cushman Lab. Foram. Research, Contr., vol. 7, p. 10, pl. 2, figs. 5, 6. Lower Temblor of California (upper Zemorrian stage of Kleinpell).—TOLMACHOFF, *1934*, Carnegie Mus., Annals, vol. 23, p. 308, pl. 40, figs. 30, 31. Miocene of Columbia.—HADLEY, *1934*, Bull. Am. Paleontology, vol. 20, no 70A, p. 18, pl. 2, fig. 15. Upper (?) Oligocene of Cuba.

Topotypes from U. S. Geol. Survey Station 6010 on the Panama Canal Zone were examined at the Cushman Laboratory. They are identical with specimens from the Carapita formation. There are from 10 to 12 costae which die out in the last-formed chamber. The aperture is at the end of a short neck and is either with or without a lip. In both the Venezuelan and Panamanian material there are a few flat-topped roughly conical specimens

which have their maximum diameter in the last chamber and taper steadily down to the initial end. These are believed to be microspheric forms. Dimensions of figured specimen: length, 0.95 mm.; diameter, 0.45 mm. Cushman Coll., no. 23,603.

Remarks.—This species is valuable for long distance correlation due to its narrow stratigraphic and wide geographic range. It appears to be largely limited to sediments of upper Oligocene and lower or lower middle Miocene age, although Dorr (1933, p. 435) has reported it from beds in southern Mexico which he considers to be of lower Oligocene age. The species is rare on Quebrada Carapita but common in the Carapita formation of the Rio Oregano.

Genus ELLIPSONODOSARIA Silvestri

ELLIPSONODOSARIA (?) VERNEUILI (d'Orbigny)

Plate 91, figure 8

Dentalina verneuili D'ORBIGNY, *1846*, Foram. Foss. Bass. Tert. Vienne, p. 48, pl. 2, figs. 7, 8. Miocene of Vienna Basin.

Nodosaria soluta Reuss, GUPPY, *1904*, Geol. Mag., dec. 5, vol. 1, p. 196, pl. 9, fig. 11. Boring at Sangre Grande, Trinidad.

Nodosaria crassielegans NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., p. 80, pl. 4, figs. 6, 7. Upper Eocene to Miocene of Trinidad.

Nodosaria verneuili (d'Orbigny), NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 81, pl. 4, figs. 14, 15. Middle Tertiary of Trinidad.

Nodosarella camerani (Dervieux), GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 41, pl. 6, figs. 9–11. Manta, Ecuador.

Ellipsonodosaria verneuili (d'Orbigny), CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 96, pl. 14, figs. 1–3. Manta, Ecuador; Aguide, Venezuela; Trinidad. —[?]CUSHMAN and JARVIS, *1930*, Jour. Paleontology, vol. 4, p. 364, pl. 33, fig. 12. Buff Bay, Jamaica.—CUSHMAN and JARVIS, *1934*, Cushman Lab. Foram. Research, Contr., vol. 10, pt. 3, pl. 10, figs. 1*a–c*.—HADLEY, *1934*, Bull. Am. Paleontology, vol. 20, no. 70A, p. 20, pl. 3, figs. 4–6. Upper (?) Oligocene and upper Eocene of Cuba.—NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 127, pl. 14, fig. 20. Pauji shale of Venezuela.

This stout-walled species is widespread in the Tertiary of tropical America. The generic designation is questionable. If the specimen with an early biserial arrangement of chambers figured by Martinotti is actually the microspheric form of *Lingulina rotundata* d'Orbigny, genotype of *Ellipsonodosaria*, then that genus is synonymous with *Nodosarella* of Rzehak and must be replaced by it on the basis of priority (see Nuttall, 1932, p. 23). None of the Carapita specimens of *E. verneuili* show any trace of biserial ancestry. Figured specimen, Cushman Coll., no. 23,604.

Genus VALVULINERIA Cushman

VALVULINERIA VENEZUELANA Hedberg, n. sp.

Plate 91, figures 21*a–c*

Trochoid, biconvex; deeply umbilicate on ventral side. About 1 to 1½ whorls visible on dorsal side. Periphery subacute in early chambers of last whorl but becoming broadly rounded and somewhat lobate in last chambers. The last whorl consists of 7 to 8 chambers, rapidly increasing in size. The final chamber occupies about a quarter of the circumference of the test and is usually separated from the penultimate chamber by a marked depression. Sutures distinct, gently curved, variably limbate; frequently raised toward the umbilicus. Wall smooth, thick, perforate, aperture covered by a heavy flap extending well into the umbilicus. Holotype from Sample E-4032. Diameter, 0.75 mm.; thickness of last chamber, 0.45 mm. Cushman Coll., no. 23,605.

Remarks.—This species resembles the California species *V. miocenica* and *V. casitasensis* in some respects. Examination of topotype material from California, supplied by R. M. Kleinpell, shows that it is distinct. The Venezuelan species is larger and coarser and its later chambers are relatively more inflated.

Genus GYROIDINA d'Orbigny

GYROIDINA SOLDANII d'Orbigny(?)

This name has been widely and loosely used for Tertiary species of *Gyroidina* in

the Caribbean region. A *Gyroidina* of this general type is rare on Quebrada Carapita but common in the Carapita formation of Rio Oregano.

Genus EPONIDES Montfort

EPONIDES UMBONATUS (Reuss) var. ECUADORENSIS (Galloway and Morrey)

Plate 91, figure 22

Rotalia ecuadorensis GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 26, pl. 3, figs. 13*a–c*. Manta, Ecuador.
Eponides umbonata (Reuss) [part], CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 98, pl. 14, figs. 8*a–c*. Manta, Ecuador; Aguide, Venezuela; middle Oligocene of Hermsdorf, Germany. —[?]NUTTALL, *1930*, Jour. Paleontology, vol. 4, p. 287. Aragon formation of Mexico. —NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 26, pl. 6, figs. 4, 5. Alazan formation of Mexico.—NUTTALL, *1935*, Jour. Paleontology, vol. 9, p. 129. Pauji shale of Venezuela.

Reuss' original figure of *Rotalina umbonata* shows a specimen with nearly straight radial sutures on the ventral side. However, Cushman (1929, p. 98) has shown that material from the type locality at Hermsdorf contains both specimens with nearly straight sutures and those with the characteristic curvature at their inner ends. The latter are predominant. Representatives of the species in the Carapita formation are almost invariably with sharply inflected sutures, and it seems desirable to distinguish them from the straight-sutured form. While clearly different from the type figured by Reuss, they are best considered a variety of that species since in the type locality in Germany there are all degrees of gradation between the two. Diameter of figured specimen, 0.30 mm. Cushman Coll., no. 23,606.

EPONIDES CREBBSI Hedberg, n. sp.

Plate 92, figures 1*a–c*

Ventral side convex; dorsal side slightly convex. About three whorls visible on dorsal side; 10 to 13 chambers in the last whorl. Periphery subacute with a narrow border of glassy shell material. Chambers gradually increasing in size. Sutures clear, very sinuous on ventral side and fused to a glassy boss at the umbo. Straight on dorsal side and tangential to the periphery of the preceding whorl. Wall distinctly perforate. Aperture a low opening at the base of the last chamber between the periphery and the umbo. Last chamber usually broken. Holotype from Sample E-4021. Diameter, 0.34 mm.; thickness, 0.21 mm. Cushman Coll., no. 23,607.

Remarks.—The sigmoid character of the sutures on the ventral side is very distinctive. The species is named in honor of C. M. Crebbs, general agent of the Venezuela Gulf Oil Company.

EPONIDES BYRAMENSIS Cushman

Plate 92, figures 2*a*, *b*

Pulvinulina byramensis CUSHMAN, *1922*, U. S. Geol. Survey, Prof. Paper 129–E, p. 99, pl. 22, figs. 4, 5. Byram marl of Mississippi.
Eponides byramensis (Cushman), COLE and GILLESPIE, *1930*, Bull. Am. Paleontology, vol. 15, no. 57B, p. 12, pl. 2, figs. 1, 2. Meson formation of Mexico.—COLE and PONTON, *1930*, Florida Geol. Survey, Bull. 5, p. 41, pl. 8, figs. 5, 6. Marianna limestone of Florida.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 26. Alazan formation of Mexico.

The Carapita specimens are very close to topotypes from Mississippi. Figured specimen, Cushman Coll., no. 23,608.

Genus SIPHONINA Reuss

SIPHONINA TENUICARINATA Cushman

Plate 92, figures 4*a*, *b*

Siphonina tenuicarinata CUSHMAN, *1927*, Jour. Paleontology, vol. 1, p. 166, pl. 26, figs. 11, 12. Alazan formation of Mexico, "and a very similar form also occurs in Trinidad." —COLE, *1927*, Bull. Am. Paleontology, vol. 14, no. 51, p. 30, pl. 5. figs. 1, 2. Guayabal formation of Mexico.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 100, pl. 14, figs. 9*a–c*. Aguide, Venezuela; Manta, Ecuador.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 26. Alazan formation of Mexico.—HADLEY, *1934*, Bull. Am. Paleontology, vol. 20, no. 70A, p. 23. Upper (?) Oligocene of Cuba.

The species seems to range from middle Eocene to middle Miocene in the Caribbean region. A form very similar to

that of the Carapita formation occurs in the Brasso formation of Trinidad but lacks the characteristic keel. Pijpers' (1933) *Siphonina? pulchra* Cushman from the upper Eocene of Bonaire is also very closely related. Diameter of figured specimen, 0.45 mm.; thickness, 0.22 mm. Cushman Coll., no. 23,609.

Genus CASSIDULINA d'Orbigny

CASSIDULINA CARAPITANA Hedberg, n. sp.
Plate 92, figures 6*a*, *b*

Test lenticular, close coiled, involute, nearly circular in outline. Periphery sharp. About 10 chambers visible. Chambers long, narrow, with little variation in size; sharply curved at inner ends. Sutures distinct; forming sharply inflected loops on the umbos. Wall smooth, finely perforate. Aperture elongate, nearly parallel to periphery of test. Holotype from Sample E-4015. Diameter, 0.22 mm.; thickness, 0.14 mm. Cushman Coll., no. 23,610.

Remarks.—This species belongs to the group of *C. laevigata* d'Orbigny, but the sutures are more sharply curved in the umbonal areas than they are in *C. laevigata* or its widely identified subspecies *carinata*.

CASSIDULINA SUBGLOBOSA Brady
Plate 92, figure 5

Cassidulina subglobosa BRADY, *1881*, Royal Micr. Soc., Quart. Jour., new ser., vol. 21, p. 60 [fide Cushman].—BRADY, *1884*, Challenger Rept., Zoology, vol. 9, p. 430, pl. 54, figs. 17*a–c*. Recent in all oceans.—CUSHMAN, *1919*, Carnegie Inst. Washington, Pub. 291, p. 35. Miocene of Cuba.—NUTTALL, *1928*, Geol. Soc. London, Quart. Jour., vol. 84, p. 78. Upper Eocene to Miocene of Trinidad.—GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 40, pl. 6, fig. 6. Manta, Ecuador.—CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 100, pl. 14, figs. 11*a*, *b*. Aguide, Venezuela.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 28. Alazan formation of Mexico.—HADLEY, *1934*, Bull Am. Paleontology, vol. 20, no. 70A, p. 23. Upper (?) Oligocene of Cuba.

Figured specimen, Cushman Coll., no. 23,611.

Genus CHILOSTOMELLA Reuss

CHILOSTOMELLA OOLINA Schwager
Plate 92, figure 3

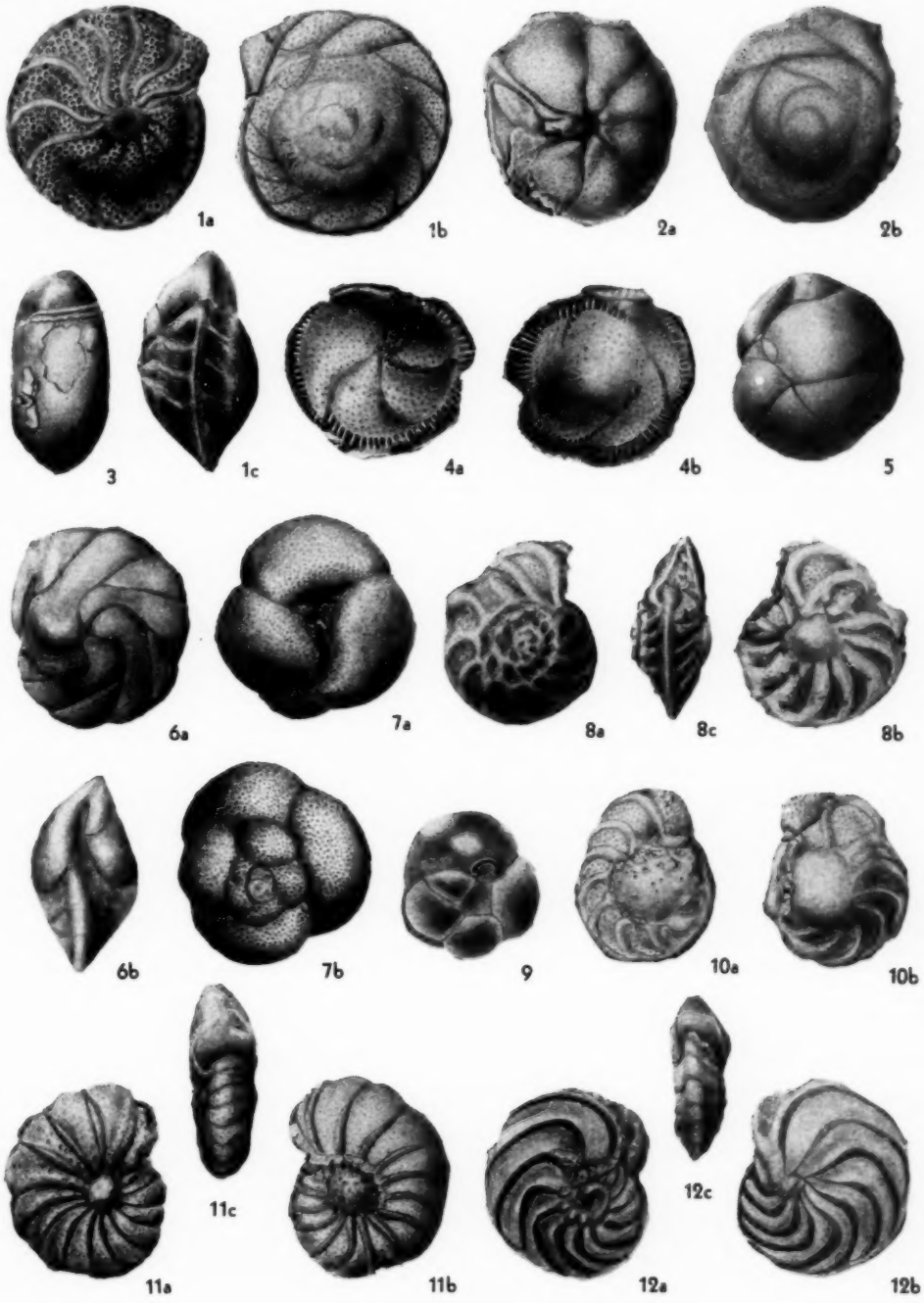
Chilostomella oolina SCHWAGER, *1878*, Com. geol. ital., Boll., vol. 9, p. 527, pl. 1, fig. 16. Pliocene.—CUSHMAN, *1926*, Cushman Lab. Foram. Research, Contr., vol. 1, p. 74, pl. 11, figs. 3–10. Recent Oceans.—CUSHMAN, *1930*, Florida Geol. Survey, Bull. 4, p. 59. Choctawhatchee formation of Florida.

Although widely known elsewhere, this species apparently has not been described previously from the Caribbean region as a fossil. It is not very common in the Carapita formation and is always poorly preserved due to the fragile char-

---

EXPLANATION OF PLATE 92

FIG. *1a–c—Eponides crebbsi* Hedberg, n. sp. Holotype, ×120. *a*, Ventral view; *b*, dorsal view; *c*, peripheral view. (p. 679)
2a, b—Eponides byramensis Cushman, ×50. *a*, Ventral view; *b*, dorsal view. (p. 679)
3—Chilostomella oolina Schwager, ×50. (p. 680)
4a, b—Siphonina tenuicarinata Cushman, ×80. *a*, Ventral view; *b*, dorsal view. (p. 679)
5—Cassidulina subglobosa Brady, ×180. (p. 680)
6a, b—Cassidulina carapitana Hedberg, n. sp. Holotype. *a*, Side view, ×180; *b*, apertural view, ×160. (p. 680)
7a, b—Globigerina venezuelana Hedberg, n. sp. Holotype, ×70. *a*, Ventral view; *b*, dorsal view. (p. 681)
8a–c—Anomalina pariana Hedberg, n. sp. Holotype, ×90. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view. (p. 681)
9—Sphaeroidina variabilis Reuss, ×80. (p. 681)
10a, b—Anomalina mecatepecensis Nuttall, ×50. *a*, Dorsal view; *b*, ventral view. (p. 682)
11a–c—Anomalina nolani Hedberg, n. sp. Holotype, ×90. *a*, Ventral view; *b*, dorsal view; *c*, peripheral view. (p. 681)
12a–c—Cibicides mantaensis (Galloway and Morrey), ×120. *a*, Dorsal view; *b*, ventral view; *c*, peripheral view. (p. 683)



Hedberg, Middle Tertiary Foraminifera

UNIV. OF MICH.

acter of its test. Figured specimen, Cushman Coll., no. 23,612.

Genus SPHAEROIDINA d'Orbigny

SPHAEROIDINA VARIABILIS Reuss
Plate 92, figure 9

Sphaeroidina variabilis REUSS, *1851*, Deutsche geol. Gesell, Zeitschr., vol. 3, p. 88, pl. 7, figs. 61–64. Middle Oligocene of Germany. —CUSHMAN, *1929*, Cushman Lab. Foram. Research, Contr., vol. 5, p. 101, pl. 14, figs. 15*a–c*. Manta, Ecuador; Aguide, Venezuela; Trinidad.

Sphaeroidina bulloides d'Orbigny var. *chilostomata* GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 32, pl. 5, fig. 1. Manta, Ecuador.

[?] *Sphaeroidina bulloides* d'Orbigny, NUTTALL *1932*, Jour. Paleontology, vol. 6, p. 29. Alazan formation of Mexico.

The Carapita formation specimens are identical with what is virtually topotype material, collected by H. G. Schenck from the Septarian clay of Germany at Kirchen-Ziegelei, 2 km. west of Freienwalde. The aperture is variable in position and consists of a elongate, arcuate opening surrounded by a not very prominent lip. The wall is smooth and polished. There is considerable variation among individual specimens. According to Nuttall (1932), there is no reliable method of separating *S. variabilis* Reuss from *S. bulloides* d'Orbigny, and it may be that the former should be placed in synonymy.

Genus GLOBIGERINA d'Orbigny

Forms which are tentatively assigned to *G. bulloides* d'Orbigny, *G. concinna* Reuss, and *G. triloba* Reuss are fairly common in the Carapita formation. These species have been frequently listed from various localities and stratigraphic horizons in the Caribbean region. The identifications are often questionable and these species of *Globigerina* are in need of revision.

GLOBIGERINA VENEZUELANA Hedberg, n. sp.
Plate 92, figures 7*a*, *b*

[cf.] *Globigerina* sp. (?) CUSHMAN and JARVIS, *1930*, Jour. Paleontology, vol. 4, p. 366, pl. 34, figs. 5*a*, *b*. Buff Bay, Jamaica.

[?] *Globigerina* cf. *apertura* Cushman, NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 29, pl. 8, figs. 1–3. Alazan formation of Mexico.

Large, nearly spherical. Chambers inflated; last three making up the bulk of the test. Early chambers form a compact spiral. Wall coarsely cancellate. Aperture in a deep triangular depression between the last chambers. Rare supplementary apertures are also present in some specimens. Holotype from Sample E-4032. Diameter of holotype, 0.56 mm. Cushman Coll., no. 23,614.

Genus GLOBIGERINELLA Cushman

GLOBIGERINELLA sp.

A species of *Globigerinella* is fairly common in samples from the Carapita formation.

Genus ANOMALINA d'Orbigny

ANOMALINA PARIANA Hedberg, n. sp.
Plate 92, figures 8*a–c*

Trochoid, equally biconvex. Three to four whorls visible on dorsal side; only the last whorl visible on ventral side. Periphery acute. Eleven to fourteen chambers in last whorl, small, gradually increasing in size. Sutures broad, raised, of whitish shell material; moderately curved on dorsal side, sharply flexed near periphery on ventral side. On ventral side sutures unite to form a glassy central boss and at their outer ends are fused to a peripheral rim. Wall between the sutures is distinctly perforate. In the early whorls seen on the dorsal side the sutures are broader than the intervening areas. Aperture peripheral. Holotype from Sample E-3093. Diameter, 0.42 mm.; thickness, 0.21 mm. Cushman Coll., no. 23,615.

ANOMALINA NOLANI Hedberg, n. sp.
Plate 92, figures 11*a–c*

Plano-convex; nearly equally involute on both sides. Ventral side flat to weakly convex; dorsal side convex. Periphery subacute. Ventral side with a glassy umbilical plug; dorsal side shows a central mass of glassy material with a few holes

representing chambers of the earlier whorls. About 15 chambers, gradually increasing in size. Sutures raised, prominent; moderately curved on both sides; thick and of glassy material. Wall coarsely perforate on dorsal side. Aperture peripheral and extending backward for five to six chambers on dorsal side. Holotype from Sample E-4032. Diameter, 0.45 mm.; thickness, 0.15 mm. Cushman Coll., no. 23,616.

Remarks.—This species is closely related to Nuttall's (1932) *A. alazanensis* from Mexico, but is less deeply umbilicate and somewhat more involute than that species. Following Cushman's (1933, p. 14) usage of the terms "dorsal" and "ventral," both *A. alazanensis* and the Venezuelan species are flattened ventrally and convex on the dorsal side. Nuttall, however, has described *A. alazanensis* as flattened dorsally and convex ventrally. In the Mexican species the chambers of the penultimate are usually clearly visible whereas in *A. nolani* they are largely hidden by the fusion of the sutures into a glassy mass. *A. nolani* is also closely related to *A. bilateralis* Cushman from the Byram marl, but that species is more nearly bilaterally symmetrical and somewhat less involute. Among living species, *A. flintii* Cushman is similar.

This species, which is characteristic of the Carapita formation, is named in honor of P. E. Nolan, chief geologist of the Venezuela Gulf Oil Company.

ANOMALINA MECATEPECENSIS Nuttall
Plate 92, figures 10*a*, *b*

Anomalina mecatepecensis NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 30, pl. 7, figs. 4, 6. Alazan formation of Mexico.

This species is identical with that figured and described by Nuttall under this name from the Alazan formation of Mexico. However, through what seems obviously to be a clerical error, a slide with different species has been labelled with this specific name and marked "Holotype" and "Paratypes." The specimens figured by Nuttall are in a second slide marked "Cotypes." I here designate the third specimen in the left-hand row of this second slide as the holotype of the species. This is the specimen figured by Nuttall on plate 7, figure 4. Both the holotype and our Venezuelan specimens are somewhat bent or twisted. The species is rare in the Carapita formation. Diameter of figured specimen, 0.63 mm. Cushman Coll., no. 23,617.

Genus CIBICIDES Montfort

CIBICIDES FLORIDANUS (Cushman) var.

A few poorly preserved specimens in the Quebrada Carapita section probably represent a variety of this species. *C. floridana* is known from the Miocene of Florida, Trinidad, and California, as well as from the present oceans. The name has included a great variety of forms.

CIBICIDES AMERICANUS (Cushman)

Truncatulina americana CUSHMAN, *1918*, U. S. Geol. Survey, Bull. 676, p. 63, pl. 20, figs. 2, 3; pl. 21, fig. 1. Choctawhatchee formation and Duplin marl of the Atlantic coast of the U. S.—CUSHMAN, *1918*, U. S. Nat. Mus., Bull. 103, p. 68, pl. 23, figs. 2*a–c*. Upper Culebra formation of Panama.—CUSHMAN, *1920*, U. S. Geol. Survey, Prof. Paper 128, p. 70, pl. 11, fig. 10. Oak Grove marl (Miocene) of Florida.—CUSHMAN, *1922*, U. S. Geol. Survey, Prof. Paper 129-E, p. 97, pl. 20, figs. 7, 8. Byram marl of Mississippi.

Cibicides americana (Cushman), CUSHMAN, *1930*, Florida Geol. Survey, Bull. 4, p. 61, pl. 12, figs. 5*a–c*. Choctawhatchee formation of Florida.—NUTTALL, *1932*, Jour. Paleontology, vol. 6, p. 32, pl. 7, figs. 10, 11. Alazan formation of Mexico.

Cibicides americanus (Cushman), COLE and GILLESPIE, *1930*, Bull. Am. Paleontology, vol. 15, no. 57B, p. 14, pl. 4, fig. 4. Meson formation of Mexico.—CUSHMAN and LAIMING, *1931*, Jour. Paleontology, vol. 5, p. 119, pl. 14, figs. 6*a–c*. Lower member of Los Sauces Creek section of California (upper Zemorrian stage of Kleinpell).—CUSHMAN and PARKER, *1931*, Cushman Lab. Foram. Research, Contr., vol. 7, p. 15, pl. 3, figs. 1*a–c*. Temblor formation of California.

Cibicides americanus (Cushman) var. *bonairensis* PIJPERS, *1933*, Geog. geol. Mededeel, Phys. geol. Reeks 8, p. 74, figs. 130–133. Upper Eocene of Bonaire, D. W. I.

This common species occurs frequently

in the Carapita formation. Elsewhere it is known from Eocene, Oligocene, and Miocene sediments. There is considerable variation in the species, but less than might be supposed from published illustrations.

CIBICIDES MANTAENSIS
(Galloway and Morrey)
Plate 92, figures 12*a–c*

Anomalina mantaensis GALLOWAY and MORREY, *1929*, Bull. Am. Paleontology, vol. 15, no. 55, p. 28, pl. 4, figs. 5*a–c*. Manta, Ecuador.

Specimens from the Carapita formation were compared with Galloway and Morrey's type and appear to be essentially identical. However, two forms (microspheric and megalospheric?) are present in the Venezuelan material. The more common, which is like the Ecuadoran type, is plano-convex, with the dorsal side flat and the ventral side gently convex. The second form (fig. 12*c*) differs from the first in being nearly equally biconvex (*Planulina*-like). It is otherwise identical and clearly belongs to the same species.

Both forms are completely involute on the ventral side and nearly so on the dorsal side. Periphery sharp. Usually 10 to 11 chambers in last whorl. Sutures distinct, sharply bent backward, limbate, of clear shell material. Wall finely perforate. Apertural face squarely truncate, extending over on to ventral side of test. Aperture peripheral, at the base of the apertural face and extending on dorsal side as a narrow slit along the inner margin of the last few chambers. Figured specimen: diameter, 0.33 mm.; thickness, 0.08 mm. Cushman Coll., no. 23,618.

Remarks.—This species is quite variable. Principal differences among individuals in the Carapita formation, other than those mentioned above, are in the breadth and elevation of the sutures and the degree of involution. Many specimens show a radiate structure at the center of the dorsal side due to incomplete fusion of the ends of the chambers. The species is very close to *Planulina marialana* Hadley (1934) from the Oligocene of Cuba, which, however, is typically larger, more coarsely perforate, and keeled, and has relatively less limbate and less sharply angled sutures. However, examination of topotype material from Hadley's 0-1 locality in Cuba, supplied by D. K. Palmer, shows that forms identical to those of the Carapita formation also occur here.

The relation of *C. mantaensis* to *C. americanus*, suggested by Galloway and Morrey, is not evident.

Genus MIOGYPSINA Sacco

MIOGYPSINA sp.

A single specimen of *Miogypsina* was found in Sample E-4028 on Quebrada Carapita. This specimen was badly damaged during sectioning, so evidence is now limited to drawings and notes made before and during sectioning. Further search failed to reveal additional specimens. Until such are found, little significance can be attached to this occurrence.

Test small, thin, biconvex, and nearly circular in outline. Maximum diameter, 1.10 mm.; minimum diameter, 1.04 mm.; thickness, 0.39 mm. Greatest thickness near center but contour somewhat elongate. Surface covered with irregularly arranged papillae up to 0.075 mm. in diameter and diminishing in size toward periphery.

Nucleoconch eccentric; about two-thirds the distance from the center of the test to the periphery. Two subequal oval embryonic chambers. The inner one is surrounded by a circlet formed by the outer one and the succeeding spiral of 6 or 7 polygonal chambers. The fifth chamber in the spiral is very small and obscure. The equatorial chambers are relatively large, quadrilateral, and defined by intersecting curves.

Of the ten species of *Miogypsina* which have been named from tropical America to date, resemblance is strongest to *M. mexicana* Nuttall (1933) from beds in Mexico "considered to be Lower Oligo-

cene in age." It differs from this species in being somewhat smaller and relatively thinner and in having a slightly more eccentric nucleoconch.

ENVIRONMENT OF DEPOSITION

The Carapita formation of the type locality is probably almost entirely of marine origin. The lower sandy member was evidently deposited in shallow water and the lateral gradation of the whole formation into coarse clastics only a few kilometers west of the type locality indicates that the shore line was not distant during the period of Carapita deposition. On the other hand, the Foraminifera of the upper member of the formation, in the light of bathymetric distribution in the present oceans, in general suggest depths of more than 100 fathoms.

Data supplied by Cushman (1918–1931), Norton (1930), and Thorp (1931) give the following information on those species living in the Caribbean region today which are also found in the Carapita formation or are closely related to Carapita species:

Ammodiscus incertus (d'Orbigny). Most known occurrences are from depths of 500 to 1,000 fathoms and at temperatures of 38.6 to 40.6 degrees F.

Bolivina aenariensis Costa. Thorp (1931) lists this species from four samples in the Caribbean Sea, all of which are from depths of more than 1,000 fathoms. On the other hand, occurrences of the related species *B. subaenariensis* Cushman are common in waters of 50 to 200 fathoms depth (Cushman, 1918–1931).

Bulimina inflata Seguenza var. *mexicana* Cushman. This species, which is closely related to *B. bleeckeri*, is apparently most common in the Caribbean region at depths of about 100 to 500 fathoms, although it has been found in a number of samples at greater depth (Cushman, 1918–1931).

Cassidulina subglobosa Brady. According to Norton (1930) this species is most common at depths of 500 to 800 fathoms.

Cyclammina cancellata Brady. Most common at depths of 500 to 1,000 fathoms (Cushman, 1918–1931; Norton, 1930).

Eponides umbonatus (Reuss). Most common below 500 fathoms (Norton, 1930).

Gaudryina atlantica (Bailey). This species, which is closely related to *Gaudryina jacksonensis* Cushman, is not recorded from the Caribbean Sea but is found off the northeastern coast of the United States at depths of 50 to 200 fathoms (Cushman, 1918–1931). With one questionable exception, the six species of *Gaudryina* identified by Norton (1930) were all found in depths of more than 500 fathoms.

Gyroidina soldanii d'Orbigny. Most of the recorded occurrences in the Caribbean region are from more than 500 fathoms depth (Cushman, 1918–1931; Norton, 1930).

Hormosina ovaliformis Cushman. Noted in samples at depths of 68 to 1,345 fathoms (Cushman, 1918–1931). Norton (1930) says the genus "is more characteristic of deep rather than shallow waters."

Nodosaria vertebralis (Batsch). This species and its variety *albatrossi* Cushman (1918–1931) has been recorded from depths of 50 to 500 fathoms, and is most abundant at depths of about 200 fathoms.

Pseudoglandulina comatula (Cushman). 100 to 400 fathoms (Cushman, 1918–1931).

Robulus calcar (Linné). Recorded by Cushman (1918–1931) from depths of 45 to 721 fathoms but most common at about 200 fathoms.

Robulus subaculeata var. *glabrata* (Cushman). This species, which is close to *Marginulina wallacei*, is living in the Gulf of Mexico and is most common at depths of about 200 fathoms (Cushman, 1918–1931).

Sphaeroidina bulloides d'Orbigny. This species, which is perhaps synonymous with *S. variabilis* Reuss, has a wide bathymetric distribution but is commonly found at depths of 500 to 1,000 fathoms (Cushman, 1918–1931).

Textularia mexicana Cushman. Common at about 200 fathoms in the Gulf of Mexico (Cushman, 1918–1931).

Textulariella barrettii (Jones and Parker). Most common in samples from 37 to 169 fathoms (Cushman, 1918–1931). A relatively shallow-water species.

Trochammina conglobata Brady. Usually found at depths greater than 350 fathoms.

Data made available by Natland (1933) on the depth distribution of foraminiferal species in the San Pedro channel of the southern California region show the following minimum depths for species which are also found in the Carapita formation or are closely related to Carapita species.

Not found at depths less than 1,000 fathoms:
- *Gyroidina soldanii* d'Orbigny
- *Sphaeroidina bulloides* d'Orbigny (? synonymous with *S. variabilis* Reuss)

Not found at depths of less than 300 fathoms:
- *Uvigerina canariensis* d'Orbigny (closely related to *U. carapitana*)
- *Bulimina inflata* Seguenza
- *Eponides umbonatus* Reuss
- *Uvigerina pygmaea* d'Orbigny

Not found at depths less than 100 fathoms:
- *Cyclammina cancellata* Brady
- *Cassidulina laevigata* d'Orbigny (closely related to *C. carapitana*)
- *Globobulimina specifica* Cushman

Found at depths of less than 100 fathoms as well as in deeper water:
- *Ammodiscus incertus* (d'Orbigny)
- *Cassidulina subglobosa* Brady.

In addition to the evidence supplied by the bathymetric data on individual Carapita species living in the present seas, the assemblage of genera represented in the Carapita formation gives further information with regard to the depth of water in which it was deposited. Thus, species of *Ammodiscus*, *Bathysiphon*, *Gaudryina*, *Gyroidina*, *Hormosina*, *Sigmoilina*, *Sphaeroidina*, and *Uvigerina*, are most common in water of more than 100 fathoms depth, and Cushman (1918–1931, pt. 4, p. 3) states that the *Lagenidae* (particularly common in the Carapita formation) are best developed in tropical regions at depths of 100 to 500 fathoms.

The absence or scarcity in the Carapita formation of the characteristic littoral and shallow water forms of the Caribbean region is perhaps as significant as the presence of typically deep-water species. Thus, *Rotalia beccarii* and species of *Elphidium*, *Planorbulinella*, and *Amphistegina* are missing and the *Miliolidae* and *Peneroplidae* are very poorly developed. Orbitoids are frequently common in Middle Tertiary shallow water fossiliferous sediments, but only one specimen (*Miogypsina* sp.) has been found in the Carapita formation. The scarcity of mollusks also harmonizes best with a rather deep-water origin for this formation.

On the other hand, geologic factors, such as the rapid lateral gradation to coarse clastics and the great thickness of the formation, oppose an origin in an open sea of any great depth and suggest that at least the formation was deposited relatively near shore and perhaps in shallower water than the Foraminifera seem to indicate. The habitat of species of Foraminifera may be controlled not only by actual depth of water but also by temperature, and conditions prevailing during Carapita time may have produced lower temperatures than exist in waters of the same depth at the present time in this region. Another possibility, which has been suggested by Clemente de Juana who has studied the type section of this formation, is that *quiet* though relatively shallow water not only permitted the deposition of this thick shale section near to shore but also allowed the development of a foraminiferal assemblage which under other conditions would be found only in much deeper water.

COMPARISON WITH OTHER FORAMINIFERAL FAUNAS OF TROPICAL AMERICA

The Carapita formation lies between strata of upper Eocene age and strata of middle Miocene or perhaps upper lower Miocene age. It is apparently separated from the overlying sediments by an angular unconformity which, however, seems to be of only local extent. Definite evidence of unconformity with the underlying formation has not yet been found, though it seems probable that such a relation exists. It is thus evident from the stratigraphic relations that the Carapita formation must have been deposited

during some part of the interval from upper Eocene to lower Miocene time inclusive. More exact age determination must be based largely on correlation by means of the foraminiferal fauna of the formation.

Many species of small Foraminifera have existed in the Caribbean region with little change throughout the whole Tertiary period, and relatively few of any considerable geographic range can be considered as limited in time to so short an interval as a Tertiary epoch. On the other hand, there is plentiful evidence not only in the present waters of this region but also in the Cenozoic sediments that environment of deposition is of tremendous importance in controlling the constitution of foraminiferal assemblages. There may be more similarity between a deep-water upper Oligocene fauna and a deep-water middle Miocene fauna than between shallow- and deep-water faunas of the same age. Age correlation of formations based merely on the percentage of like species is exceedingly dangerous and may indicate likeness of facies rather than contemporaneity of deposition. Only where faunas are definitely homeotopic (Williams, 1903; Schenck, 1928) is percentage of like or different species a dependable guide to relative age. Of greater value in synchronization is the presence of even a few species for which previous records give good evidence of a limited stratigraphic range.

Comparisons of the Carapita foraminiferal assemblage with those of other formations given in the following pages are based not only on the published literature but in most cases also on the study of actual samples.

Trinidad.—No very comprehensive work on the abundant Tertiary Foraminifera of Trinidad has yet appeared. Guppy (1893, 1904) discussed Foraminifera in several of his papers and listed many species. Only a few of these were figured, however, and the specific names alone carry little meaning at the present time. Nuttall (1928), Cushman and Jarvis (1929, 1934), and Cushman (1936) have made valuable contributions more recently. Mr. Jarvis has kindly supplied me with faunal lists and photographs illustrating the distribution of index species, and I have examined many hundreds of foraminiferal samples from this island. The general stratigraphy of Trinidad has recently been outlined by Lehner (1935) and Kugler (1936), to whose works reference should be made.

Carapita species are represented in many of the Oligocene and Miocene formations of Trinidad, and since the area of this island formed part of the same general basin in which the Carapita formation was deposited, it is to be expected that sediments of Carapita age should be found here. I have found assemblages at two localities which very closely approach that typical of the Carapita formation. These are: (1) the crest of the structure exposed in Cedar Hill Ravine, Forest Park Estate, just north of the Central Range; and (2) shale in the stream bed of the Mayo River at Mayo Quarry. According to information kindly supplied by H. G. Kugler and E. Lehner, these two horizons are of approximately the same age and lie just below the Guaracara limestone horizon and within the upper Oligocene Alley Creek formation of Kugler (1936). In samples from these localities occur characteristic species of the middle zone of the Carapita formation such as the following:

Carapita Species of Foraminifera from Trinidad

Anomalina mecatepecensis Nuttall
Eponides crebbsi Hedberg, n. sp.
Gaudryina jacksonensis Cushman
Marginulina wallacei Hedberg, n. sp.
Nodosaria vertebralis (Batsch)
Plectofrondicularia californica Cushman and Stewart
Pseudoglandulina comatula (Cushman)
Robulus calcar (Linné)
Robulus clericii (Fornasini)
Siphogenerina transversa Cushman
Sphaeroidina variabilis Reuss
Textularia mexicana Cushman
Textulariella barrettii (Jones and Parker)
Uvigerina carapitana Hedberg, n. sp.

Many of the species described by Nut-

tall (1928) are present in the Carapita formation. However, due to the complicated geology of the Naparima area and the lack of continuous outcrop sections, the stratigraphic position of some of these occurrences is rather questionable. Of the several units which Nuttall discusses, the Carapita formation is most closely related paleontologically to the Williamsville clay, which Kugler (1936, p. 1451) considers as also belonging to his Alley Creek formation.

Northwestern Venezuela.—Little has been published on the Tertiary smaller Foraminifera of Venezuela, although much information is now in the files of various petroleum companies which have carried on active micropaleontological work here during the last 10 years.

(1) Maracaibo Basin. The Pauji shale of upper Eocene age is lithologically very similar to the Carapita formation but the general aspect of its foraminiferal fauna is quite different. The fauna of the upper part of the Pauji shale has been described recently by Nuttall (1935). Of the species which he mentions, only the following long-ranging forms are common to the Carapita formation:

Foraminifera of the Pauji Shale (Upper Eocene) also Found in the Carapita Formation

Ammodiscus incertus (d'Orbigny)
Cyclammina cancellata Brady
Dentalina adolphina (d'Orbigny)
Ellipsonodosaria verneuili (d'Orbigny)
Gyroidina soldanii d'Orbigny
Nodosaria longiscata d'Orbigny
Plectofrondicularia vaughani Cushman

The so-called Mene Grande formation, overlying the Pauji shale and also of upper Eocene age, shows even less similarity to the Carapita formation in its microfauna. Younger sediments of the Maracaibo Basin are largely of nonmarine origin, with the exception of the La Rosa formation of upper Oligocene-lower Miocene age. This formation carries a typical shallow-water marine foraminiferal assemblage and due to its facies character, if for no other reason, shows little faunal similarity to the Carapita formation. This is essentially true also for the Oligocene and Miocene formations of western and central Falcon which are largely shallow water deposits (Agua Clara formation, Cerro Pelado formation, Socorro formation, Urumaco formation).

(2) Eastern Falcon. In the eastern part of the State of Falcon, Tertiary deposits are in general of deeper water origin and greater facies similarity to the Carapita formation is to be expected. Senn (1935, pp. 75, 76) has shown that Middle Tertiary sediments here may be divided into two groups on the basis of their small Foraminifera. The upper Eocene, lower Oligocene, and middle Oligocene formations (Pauji shale, Cerro Mission shale, Guayaval marl, San Luis formation) carry the so-called *Guayaval* foraminiferal assemblage, while the upper Oligocene and Miocene formations (Agua Salada group, including the eastern equivalents of the Agua Clara, Cerro Pelado, Socorro, and Urumaco formations) carry a distinct assemblage known as the *Agua Salada* fauna. Examination of numerous samples from these two assemblages shows without doubt that the fauna of the Carapita formation belongs with that of the Agua Salada group.

The Agua Salada group includes many thousands of feet of highly foraminiferal sediments but due to uniformity of facies there is relatively little change in the character of the fauna, though the age of the strata ranges from upper Oligocene to upper Miocene. However, a few species have limited ranges within the group, and on the basis of these Senn has divided it into six zones which he has named in order from oldest to youngest: A4, A3–A4, A3, A2, A1a, and A1c (1935, p. 76). Many of the Carapita species are found in several of these zones but the greatest similarity is clearly with the A4 zone. Not only is there a greater total number of species in common with this zone than with any other, but also the Carapita formation carries most of the index species which separate the A4 zone from other zones in the Agua Salada group.

The A4 zone is typically developed in

the shales immediately overlying the El Mene sand in the El Mene de Acosta oil field of eastern Falcon (Senn, 1935). Study of samples of the zone obtained from these wells through the courtesy of the North Venezuelan Petroleum Company shows the following species in common with the Carapita formation:

Foraminifera Common to the A4 Zone of the Agua Salada Group and the Carapita Formation

Anomalina nolani Hedberg, n. sp.
Anomalina pariana Hedberg,n. sp.
Bulimina cf. *inflata* Seguenza
Chilostomella oolina Schwager
Cibicides mantaensis(Galloway and Morrey)
Clavulina curta Galloway and Morrey
Ellipsonodosaria verneuili (d'Orbigny)
Eponides crebbsi Hedberg, n. sp.
Eponides umbonatus (Reuss)
Gaudryina jacksonensis Cushman
Globigerina venezuelana Hedberg, n. sp.
Globobulimina cf. *pacifica* Cushman
Gyroidina soldanii d'Orbigny
Hormosina ovaliformis Cushman
Marginulina wallacei Hedberg, n. sp.
Nodosaria longiscata d'Orbigny
Nodosaria nuttalli Hedberg, n. sp.
Nodosaria raphanistrum var. *caribbeana* Hedberg, n. var.
Nodosaria vertebralis (Batsch)
Nonion belridgensis Barbat and Johnson
Planularia venezuelana Hedberg, n. sp.
Pseudoglandulina comatula (Cushman)
Robulus calcar (Linné)
Robulus clericii (Fornasini)
Saracenaria schencki Cushman and Hobson
Siphogenerina transversa Cushman
Siphonina tenuicarinata Cushman
Sphaeroidina variabilis Reuss
Textulariella barrettii (Jones and Parker)
Uvigerina pygmaea var. *capayana* Hedberg, n. var.
Valvulineria venezuelana Hedberg, n. sp.

There are also many other closely related forms, and correlation between at least the middle zone of the Carapita formation and the A4 zone of the Agua Salada group seems very definite. Senn (1935) has correlated the sediments of the A4 zone with those of the Agua Clara formation of central Falcon. The two show very few species in common but represent deep and shallow water facies of deposition respectively. The Agua Clara formation is generally considered to be of upper Oligocene age.

A foraminiferal fauna from near the town of Aguide has been described by Cushman (1929). The Aguide horizon falls in Senn's A3 zone, and although more than 20 of the Aguide species also occur in the Carapita formation the stratigraphic horizon is not believed to be the same. As shown above, there is an even greater number of Carapita species in the A4 zone, which is stratigraphically below the Aguide horizon, and, furthermore, the Carapita formation possesses several species which are not known in eastern Falcon above the A4 zone. I agree with Cushman and Senn in placing the Aguide horizon in the Miocene (Senn, 1935, p. 77, footnote 29), and believe that Dorr's (1933) assignment of this horizon to the lower Oligocene is due to mistaking facies similarity for contemporaneity.

Colombia.—Unfortunately, almost nothing has been published concerning the highly foraminiferal Middle Tertiary formations of the northern part of the Magdalena Valley. Tolmachoff (1934) has recently described a Miocene assemblage from the Atrato River Valley of western Colombia. *Siphogenerina transversa* Cushman is the only species of any stratigraphic importance which is common to the Carapita formation. The Colombian horizon seems to be considerably younger.

I recently examined Foraminifera from samples of the Las Perdices shale collected by H. G. Schenck near Puerto Colombia on the north coast. This fauna is clearly younger than that of the Carapita formation and appears to be of early middle Miocene age (Schenck, 1935a, pp. 504, 505).

Bonaire.—Upper Eocene smaller Foraminifera have been described by Pijpers (1933) from the Dutch island of Bonaire, lying just off the coast of northwestern Venezuela. H. G. Schenck kindly supplied me with a sample of topotype material obtained through the courtesy of L. Rutten. A list of species common to the Carapita formation found in this material or mentioned in Pijpers' report follows:

Foraminifera Common to Upper Eocene Beds of Bonaire and the Carapita Formation

Bulimina bleeckeri Hedberg, n. sp.
Cibicides americanus (Cushman)
Ellipsonodosaria verneuili (d'Orbigny)
Eponides byramensis Cushman
Globobulimina cf. *pacifica* Cushman
Nodosaria pariana Hedberg, n. sp.
Nodosaria nuttalli Hedberg, n. sp.

Most of these are rather long-ranging forms and there is no reason to believe the two formations are time equivalents.

Ecuador.—An assemblage of small Foraminifera from near Manta, Ecuador, has been described by Galloway and Morrey (1929), who concluded that the fauna was upper Eocene in age. Later in the same year Cushman (1929) studied the same fauna and definitely stated that it was not Eocene but much younger. He remarked that many of the species were widely distributed in the later Oligocene and especially the Miocene of America and Europe. Dorr (1933) has recently considered the Manta fauna as lower Oligocene, equivalent to that of the Alazan formation of Mexico. Lacking knowledge of the stratigraphy of this region, I can venture no opinion further than that the Manta fauna appears to be younger than upper Eocene and older than middle Miocene. I have examined Galloway and Morrey's types at Columbia University and found the following species common to the Carapita formation:

Foraminifera Common to the Manta Fauna of Ecuador and the Carapita Formation

Cassidulina subglobosa Brady
Cibicides mantaensis (Galloway and Morrey) = *Anomalina mantaensis* Galloway and Morrey
Clavulina curta Galloway and Morrey
Dentalina adolphina d'Orbigny
Ellipsonodosaria verneuili (d'Orbigny) = *Nodosarella camerina* (Dervieux), Galloway and Morrey
Eponides umbonatus var. *ecuadorensis* Galloway and Morrey
Nodosaria longiscata d'Orbigny = *N. arundinea* Schwager, Galloway and Morrey
Nodosaria vertebralis (Batsch)
Plectofrondicularia californica Cushman and Stewart
Plectofrondicularia vaughani Cushman = *Flabellina budensis* Hantken, Galloway and Morrey
Pseudoglandulina comatula (Cushman) = *Glandulina comata* (Batsch), Galloway and Morrey
Robulus calcar (Linné)
Sphaeroidina variabilis Reuss = *S. bulloides* var. *chilostomata* Galloway and Morrey

Panama.—Foraminifera have been described from the Culebra, Emperador, and Gatun formations of Panama by Cushman (1918). These show little apparent relation to the Carapita fauna. However, the original description of *Siphogenerina transversa* is contained in this publication. I examined topotypes of this species from U. S. Geol. Survey Station 6010 at the Cushman Laboratory and found that they agreed very closely with specimens from the Carapita formation. The Panama occurrence is from the lower part of the Culebra formation (middle or upper Oligocene age).

Costa Rica.—None of the species described by Katherine Van Winkle Palmer (1923) from the Uscari formation of Costa Rica occur in the Carapita formation. Some of the original material from the Cahuita well was examined at Stanford University, but only a few species were found which showed any relation to those of the Carapita formation. The Costa Rican material appears to be younger.

Nicaragua.—About 50 species of Foraminifera are listed by Dorr (1933) from a shale formation in Nicaragua lying between upper Eocene and Miocene strata. No descriptions or figures are given, so that the latitude of variation allowed in specific identification is unknown. However, it seems fairly certain that at least a dozen Carapita species are present in this material. Dorr correlates the Nicaraguan horizon with the Alazan formation of Mexico, with the Aguide horizon of Venezuela, and with the Manta horizon of Ecuador. Since an almost equally valid correlation might also be made with the Carapita formation, it seems evident that the basis for Dorr's correlation is similarity of facies rather than equivalence of age. All of

these deposits represent a fairly deep-water Middle Tertiary shale facies and their relative stratigraphic positions can be determined only by very detailed work.

Mexico.—Tertiary smaller Foraminifera of the Tampico embayment have been described from the Guayabal formation (upper middle Eocene) and the Chapapote formation (upper Eocene) by Cole (1927, 1928), from the Meson formation (middle Oligocene) by Cole and Gillespie (1930), from the Alazan formation (lower Oligocene) and from the Aragon formation (upper lower Eocene) by Nuttall (1930, 1932) and from various horizons by Cushman.[3] Thalmann (1935) has recently listed species from the type Tuxpan formation (lower Miocene).

The Carapita fauna shows little relation to those of the Aragon, Guayabal, and Chapapote formations and there are only a few species in common with the Meson and Tuxpan formations. The Alazan fauna described by Nuttall, however is strikingly similar. A list of Carapita species occurring in the Alazan formation follows:

Foraminifera Common to the Alazan Formation of Mexico and the Carapita Formation

Ammodiscus incertus (d'Orbigny)
Anomalina mecatepecensis Nuttall
Bolivina alazanensis Cushman
Bulimina bleeckeri Hedberg, n. sp.
Cassidulina subglobosa Brady
Cibicides americanus Cushman
Dentalina adolphina d'Orbigny
Dorothia nuttalli Cushman
Eponides byramensis Cushman
Eponides umbonatus (Reuss) var. *ecuadorensis* Galloway and Morrey
Gaudryina jacksonensis Cushman
Globigerina venezuelana Hedberg, n. sp. = *G.* cf. *apertura* Cushman and Nuttall
Gyroidina soldanii d'Orbigny
Marginulina sublituus (Nuttall)
Nodosaria longiscata d'Orbigny
Nodosaria nuttalli Hedberg, n. sp. = *N.* aff. *carinata* (Neugeboren), Nuttall
Nodosaria raphanistrum var. *caribbeana* Hedberg, n. var.
Nodosaria vertebralis (Batsch)
Plectofrondicularia vaughani Cushman
Pseudoglandulina comatula (Cushman)
Sigmoilina tenuis (Czjzek)
Siphonina tenuicarinata Cushman
Sphaeroidina variabilis Reuss = *S. bulloides* d'Orbigny, Nuttall
Uvigerina carapitana Hedberg, n. sp. = *U. canariensis* d'Orbigny, Nuttall
Uvigerina pygmaea d'Orbigny

There are also a number of other very closely related forms. The *Miogypsina* sp. of the Carapita formation is near to that described by Nuttall (1933) as *M. mexicana*, from beds "considered to be lower Oligocene in age and . . . associated with a microforaminiferal fauna bearing many Alazan species." It is noteworthy that none of the forms listed by Nuttall as particularly characteristic of the lower Alazan appear in the Carapita formation. The upper Alazan clearly represents a facies similar to that of the Carapita formation.

Foraminifera of stratigraphic value in the Tertiary formations of the Isthmus of Tehuantepec have been listed recently by Thalmann (1935). Some Carapita species occur in the Deposito beds (Oligocene), the Ixhuatlan beds (lower Miocene), and the Concepcion beds (lower Miocene), but with the available information there is little basis for correlation. The presence of *Siphogenerina transversa* Cushman in the Concepcion beds may be significant.

Dorr (1933) has listed numerous species from shale near Papantla which he correlates with the Alazan formation. Many of these species occur in the Carapita formation, but as mentioned above, this may indicate no more than similarity of facies. Thalmann (1935, p. 596; 1935a, p. 545) refers to "Papantla beds" which he considers lower Miocene in age. It is not known if these are the same strata which Dorr places in the lower Oligocene.

Cuba.—Three collections of Foraminifera from the Tertiary of Cuba have been described by Hadley (1934). Collection 0-1 "appears to be of Oligocene age, probably upper." Collection 0-2 is

[3] For a complete list of references on micropaleontology in Mexico, see R. W. Barker, Micropaleontology in Mexico with special reference to the Tampico embayment: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 20, pp. 433–456, 1936.

also considered as probably Oligocene. Collection E-1 is upper Eocene. The Carapita formation fauna shows no affinity to the 0-2 and E-1 assemblages, but contains many species in common with the 0-1 collections. I examined Hadley's types at the Paleontological Institution in Ithaca and through the kindness of D. K. Palmer obtained topotype material from the 0-1 locality. The following 0-1 species occur in the Carapita formation, those mentioned by Hadley being marked by asterisk, and the rest being found in my topotype material.

Foraminifera Common to Hadley's 0–1 Collections from Cuba and the Carapita Formation

Cassidulina subglobosa Brady*
Dentalina adolphina d'Orbigny*
Ellipsonodosaria verneuili (d'Orbigny)*
Plectofrondicularia vaughani Cushman*
Siphogenerina transversa Cushman*
Siphonina tenuicarinata Cushman*
Cibicides mantaensis (Galloway and Morrey)
Gyroidina soldanii d'Orbigny
Nodosaria longiscata d'Orbigny
Nodosaria nuttalli Hedberg, n. sp.
Nodosaria pariana Hedberg, n. sp.
Nodosaria vertebralis (Batsch)
Pseudoglandulina comatula (Cushman)

The Carapita microfauna shows no relation to the Upper Tertiary foraminiferal assemblage recently described by Palmer and Bermudez (1936) from the Matanzas Bay region. Neither is there much resemblance to the Miocene microfauna from Yumuri gorge discussed by Cushman (1919, p. 29.)[4]

Jamaica.—Foraminifera have been described from Bowden by Cushman (1919) and from Buff Bay by Cushman and

[4] Since the preparation of this manuscript, I have received copies of several new publications on the smaller Foraminifera of Cuba which are not included in the list of references and the synonymies.

Cushman and Bermudez (*Cushman Lab. Foram. Research, Contr.*, vol. 12, pt. 2, pp. 27–38, 1936, and vol. 13, pt. 1, pp. 1–28, 1937) have described and figured more than 80 new species and varieties from the Eocene of Cuba. None of these has been found in the Carapita formation. It is noteworthy, however, that a variety of *Siphogenerina transversa* (*S. transversa cubensis* Cushman and Bermudez) occurs in these Eocene beds of Cuba.

Palmer and Bermudez (*Soc. cubana hist. nat., Mem.*, vol. 10, no. 4, pp. 227–271, 1936, and vol. 10 no. 5, pp. 273–316, 1936) have described and discussed a fauna of 182 species and varieties of small Foraminifera from the Oligocene of Cuba which is of great interest in connection with the Carapita fauna. The following species mentioned by Palmer and Bermudez are found in the Carapita formation or are closely related to Carapita species:

Foraminifera Common to the Oligocene of Cuba and the Carapita Formation

Ammodiscus aff. *A. incertus* (d'Orbigny)
Cyclammina cf. *C. cancellata* Brady
Textularia mexicana Cushman var. *cubana* Palmer and Bermudez (closely related to *T. mexicana* Cushman of Carapita formation)
Gaudryina (*Pseudogaudryina*) *jacksonensis* Cushman
Heterostomella? cubensis Palmer and Bermudez (closely related, if not identical with, *H. halconi* Hedberg)
Clavulina curta Galloway and Morrey
Dorothia nuttalli Cushman
Sigmoilina tenuis (Czjzek)
Nodosaria longiscata d'Orbigny
Nodosaria raphanistrum (Linné)
Nodosaria sp. A. (close to *N. vertebralis* (Batsch))
Pseudoglandulina comatula (Cushman)
Saracenaria schencki Cushman and Hobson (close to *S. senni* Hedberg)
Plectofrondicularia vaughani Cushman
Bulimina inflata Seguenza
Bulimina ovata d'Orbigny
Bulimina cf. *pupoides* d'Orbigny
Bolivina alazanensis Cushman
Uvigerina canariensis d'Orbigny var. (close to *U. carapitana* Hedberg)
Ellipsonodosaria verneuili (d'Orbigny)
Eponides byramensis (Cushman) var. *cubensis* Palmer and Bermudez (close to *E. byramensis* (Cushman) of Carapita formation)
Eponides umbonatus (Reuss)
Siphonina tenuicarinata Cushman
Cassidulina subglobata Brady
Sphaeroidina bulloides d'Orbigny (synonymous with *S. variabilis* Reuss?)
Globigerina cf. *bulloides* d'Orbigny
Anomalina alazanensis Nuttall (close to *A. nolani* Hedberg)
Cibicides cf. *floridanus* (Cushman)

On the basis of comparison with Norton's (1930) data from the Caribbean Sea, the authors conclude that their fauna probably accumulated at a depth of 100 to 500 fathoms. This compares closely with the conclusion reached with respect to the similar Carapita fauna. The authors consider the Cuban fauna

Jarvis (1930). The assemblage from the latter locality represents deeper water deposition and shows more similarity to the Carapita fauna than does that from Bowden. Species common to the Buff Bay horizon and the Carapita formation include *Ellipsonodosaria verneuili* (d'Orbigny), *Plectofrondicularia vaughani* Cushman, *Robulus calcar* (Linné), and a few other forms, but this Jamaican Miocene horizon seems to be distinctly younger than the Carapita formation.

Santo Domingo.—Cushman (1919) lists Foraminifera from several horizons in the Tertiary sediments of Santo Domingo, but there is no resemblance to the Carapita fauna.

Southeastern United States.—There is little apparent relation between the Carapita foraminiferal fauna and that of any of the Tertiary formations of Florida and the Gulf Coast from which Foraminifera have been described. The most cosely related fauna which I have seen from this region is one which was kindly supplied by J. B. Garrett of the Stanolind Oil and Gas Company from deep wells in the Hackberry field, Cameron Parish, La. This contains:

Foraminifera from Wells in Cameron Parish, Louisiana

Bolivina alazanensis Cushman
Chilostomella aff. *oolina* Schwager
Ellipsonodosaria verneuili (d'Orbigny)
Eponides crebbsi Hedberg, n. sp.
Eponides umbonatus Reuss
Globigerina venezuelana Hedberg, n. sp.
Gyroidina soldanii d'Orbigny
Marginulina sublituus (Nuttall)
Nodosaria longiscata d'Orbigny
Nodosaria raphanistrum (Linné)
Robulus clericii (Fornasini)
Siphonina tenuicarinata Cushman
Sphaeroidina variabilis Reuss
Uvigerina carapitana Hedberg, n. sp.

Mr. Garrett regards this fauna, which he has referred to temporarily as the "Alazan" fauna, as basal Miocene or upper Oligocene.

California.—Study of the numerous published descriptions of Tertiary foraminiferal faunas from this state and comparison with actual samples made available through the kindness of H. G. Schenck show the presence of a number of Carapita species in several of the California assemblages. There is a marked similarity between the microfauna of the upper part of the San Lorenzo formation, described by Cushman and Hobson (1935), and that of the Carapita formation. The following rather distinctive species are common to both:

Foraminifera Common to the San Lorenzo and Carapita Formations

Bolivina alazanensis Cushman var. *venezuelana* Hedberg = *Bolivina* sp. Cushman and Hobson
Globulimina cf. *pacifica* Cushman
Plectofrondicularia vaughani Cushman
Pseudoglandulina comatula Cushman = *P. gallowayi* Cushman, Cushman and Hobson
Saracenaria schencki Cushman and Hobson (very close to *S. senni* Hedberg)

A few Carapita species are present in the assemblage described by Cushman and Parker (1931) from the east side of the San Joaquin Valley. These include *Siphogenerina transversa* Cushman and *Cibicides floridanus* Cushman. Barbat and von Estorff's (1933) Vaqueros assemblage from the southern part of the San Joaquin Valley contains a number of species in common with the Carapita formation, as does also the lower part of the Los Sauces Creek section described by Cushman and Laiming (1931).

A succession of Tertiary stages has recently been indicated in California by

---

to be of lower Oligocene age, and a correlative of the Alazan formation of Mexico. They also apparently consider it to be the time equivalent of the faunas from Papantla, Mexico, and from Nicaragua mentioned by Dorr (1933), of the Manta, Ecuador, fauna of Galloway and Morrey (1929), of the Aguide fauna of Cushman (1929), and the 0–1 fauna of Hadley (1934) from Marel (=Mariel?), Cuba. As mentioned previously, I am inclined to believe that the similarity of these foraminiferal assemblages may be due more to similarity of environment than to exact contemporaneity.

Thiadens (*Jour. Paleontology*, vol. 11, pp. 91–109, 1937) and Hanzawa (*Jour. Paleontology*, vol. 11, pp. 110–117, 1937) have recently discussed larger Foraminifera from Cuba, but none of the species mentioned are known from the Carapita formation.—H. D. Hedberg, May, 1937.

R. M. Kleinpell (1934) (Schenck and Kleinpell, 1936). The upper part of the San Lorenzo formation, with which the Carapita formation shows the greatest affinity, is placed by Kleinpell (personal communication) in the lower part of his Zemorrian stage. The Cushman and Parker assemblage falls in the lower Saucesian; that of Barbat and von Estorff is lower Zemorrian, and the lower part of the Los Sauces Creek section is upper Zemorrian. The Zemorrian stage of Kleinpell may be considered as of approximately early upper Oligocene or late middle Oligocene age.

CONCLUSIONS ON AGE AND CORRELATION

On the basis of its Foraminifera, the middle zone of the Carapita formation is believed to be approximately equivalent in age to Senn's A4 zone (Agua Clara stage) of northwestern Venezuela and to a horizon of the Alley Creek formation of Trinidad immediately underlying the Guaracara limestone. Not only does it possess many species in common with these formations, but it is characterized by a few species which seem to be confined to them. The danger of mistaking similarity of facies for age equivalence is lessened by the fact that in both northwestern Venezuela (eastern Falcon) and in Trinidad foraminiferal sediments of a fairly deep water shale facies similar to that of the Carapita formation are known for almost the whole of Middle Tertiary time (upper Eocene to middle Miocene inclusive). Thus, while the Carapita formation has many species in common with the Aguide beds (lower or middle Miocene) of eastern Falcon and the Cipero group (lower and middle Oligocene) of Trinidad, its closer relation to the A4 zone and the Alley Creek formation in these two regions respectively is particularly significant, since the lithologic facies is apparently not any more similar.

The difficulties involved in differentiating mere similarity of facies from age equivalence are greater in correlation with other more distant areas. It is evident that the Carapita fauna is related to the faunas of the Marel marl of Cuba (Hadley's 0-1 horizon), the Alazan formation of Mexico, the so-called "Alazan" horizons of Louisiana, the Manta beds of Ecuador, and the upper San Lorenzo formation of California. However, only in the last case do we have sufficient general stratigraphic information to feel assured of an approximate time correlation. The sediments of Kleinpell's Zemorrian stage contain more of the distinctive species of the Carapita formation than do sediments of any of the other Middle Tertiary stages of California, even though their depositional facies are equally close to that of the Carapita formation. This fact is believed to be good evidence for the approximate synchronization of the Venezuelan formation with the Zemorrian stage.

The question of the absolute age of the Carapita formation in terms of the generally accepted time scale is difficult to answer. Terms such as Oligocene and Miocene are convenient in that they have world-wide usage, but it must be recognized that they have no very exact significance. Since there is no agreement as to their stratigraphic scope, even in the region of their origin (western Europe),[5] it is evident that their meaning cannot be very definite as applied to the Caribbean region. Moreover, at the present time, correlation of even the more definitely established time-stratigraphic terms (stages) of Europe with the Caribbean region is very uncertain, although some progress is being made (Woodring, 1928; Rutsch, 1934).

Granting the validity of Senn's correlation of the A4 zone of El Mene de Acosta in the eastern part of the State of Falcon with the type Agua Clara formation in Central Falcon, the middle zone of the Carapita formation falls definitely in the Agua Clara stage. The consensus of opinion would place this stage

[5] As witness the Danian-Montian controversy, the Bartonian-Tongrian controversy, and the Aquitanian-Burdigalian controversy.

TABLE 2.—Stratigraphic distribution of Carapita species in tropical America.

in the upper Oligocene[6] (Senn, 1935, p. 78; Liddle, 1928, p. 261). The Alley Creek beds of Trinidad, to which the middle zone of the Carapita formation may also be correlated, are likewise believed to be of upper Oligocene age (Kugler, 1936). The Zemorrian stage of California is at least in part of upper Oligocene age.

The Marel marl of Cuba is considered by Hadley (1934) to be probably of upper Oligocene age, and hence its faunal similarity to the Carapita formation is in keeping with the probable age relations of the two formations. Sufficient stratigraphic information regarding the Manta beds of Ecuador and the "Alazan" of Louisiana is not available to me to allow any definite opinions as to their stratigraphic position.

The Alazan[7] formation of Mexico shows marked faunal similarity to the Carapita formation, yet it is generally considered to be of lower Oligocene age (Cooke, 1928; Barker, 1936, p. 438; Nuttall, 1932). Granting the correctness of this view, I am inclined to believe that the similarity is due not to age equivalence but to the fact that the Alazan more than any other Middle Tertiary formation of Mexico closely approaches a facies such as that represented by the Carapita formation. Upper Oligocene foraminiferal sediments are apparently unknown in this part of Mexico, and the middle Oligocene Meson and lower Miocene Tuxpan formations are both shallow water deposits. If an upper Oligocene formation of facies similar to that of the upper Alazan formation were present in this region, it would probably show even greater faunal similarity to the Carapita formation than does the Alazan.

The stratigraphic ranges of the Carapita species in the Caribbean region and adjacent provinces, based on published data and on additional occurrences listed in this paper, are shown graphically in Table 2. The assembled data clearly indicate that the age of the formation must lie between upper Eocene and lower Miocene, and the bulk of the evidence seems to point to upper Oligocene. Conclusions based on this chart are, of course, open to question because of incomplete data on occurrences, errors in identification of species, the difficulty of evaluating the influence of depositional facies, and the lack of unanimity of opinion regarding the age of formations from which species have been reported.

Assuming the correctness of an upper Oligocene age for the middle zone of the Carapita formation and the correlations advanced above, it can also be considered as the approximate time equivalent of the Culebra stage of Panama-Costa Rica, the Anguilla stage of the West Indies, and the uppermost part of the Vicksburg stage of the Gulf Coast of the United States, although direct faunal correlations with these are not yet possible. It must be remembered, however, that this middle zone of the Carapita formation is only a relatively small part of a very thick formation and that while there seem to be only slight stratigraphic differences in the fauna throughout the formation, it is possible that the barren lower part of the formation may extend farther down in the Oligocene while the upper part may reach into the lower Miocene.

[6] I am inclined to follow those who would place the Aquitanian stage in the upper Oligocene rather than in the lower Miocene. For a recent discussion of this subject see Schenck, 1935.

[7] The term Huasteca has recently been proposed for the Oligocene part of what was orginally called Alazan (see J. M. Muir, Geology of the Tampico Region, Mexico: *Am. Assoc. Petroleum Geologists*, Tulsa, Okla., 1936.

REFERENCES

BARBAT, W. F., and VON ESTORFF, F. E., *1933*, Lower Miocene Foraminifera from the southern San Joaquin Valley, California: *Jour. Paleontology*, vol. 7, no. 2, pp. 164–174.

BARKER, R. W., *1936*, Micropaleontology in Mexico, with special reference to the Tampico embayment: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 20, no. 4, pp. 433–456.

COLE, W. S., *1927*, A foraminiferal fauna from the Guayabal formation in Mexico: *Bull. Am. Paleontology*, vol. 14, no. 51, 46 pp.

———, *1928*, A foraminiferal fauna from the Chapapote formation in Mexico: *Bull. Am. Paleontology*, vol. 14, no. 53, pp. 200–232.

———, and GILLESPIE, R., *1930*, Some small Foraminifera from the Meson formation of Mexico: *Bull. Am. Paleontology*, vol. 15, no. 57B, 15 pp., 4 pls.

COOKE, C. W., *1928*, New Vicksburg (Oligocene) mollusks from Mexico: *U. S. Nat. Mus., Proc.*, vol. 73, art. 10, 11 pp.

CUSHMAN, J. A., *1918*, The smaller fossil Foraminifera of the Panama Canal Zone: *U. S. Nat. Mus., Bull.* 103, pp. 45–87.

———, *1919*, Fossil Foraminifera from the West Indies: *Carnegie Inst. Washington, Pub.* 291, pp. 21–72.

———, *1929*, A Late Tertiary fauna of Venezuela and other related regions: *Cushman Lab. Foram. Research, Contr.*, vol. 5, pt. 4, pp. 77–101, 3 pls.

———, *1918–1931*, The Foraminifera of the Atlantic Ocean: *U. S. Nat. Mus., Bull.* 104, pts. 1–8.

———, *1933*, *Foraminifera, their classification and economic use*, 2d ed., Norwood Press, Norwood, Mass.

———, *1936*, New genera and species of the families Verneuilinidae and Valvulinidae and of the subfamily Virgulininae: *Cushman Lab. Foram. Research, Special Pub.* 6, Sharon, Mass.

——— and HOBSON, H. D., *1935*, A foram-i niferal faunule from the type San Lorenzo formation, Santa Cruz County, Calif.: *Cushman Lab. Foram. Research, Contr.*, vol. 11, pt. 3, pp. 53–64, 2 pls.

——— and JARVIS, P. W., *1929*, New Foraminifera from Trinidad: *Cushman Lab. Foram. Research, Contr.*, vol. 5, pt. 1, pp. 6–17, 1 pl.

——— and JARVIS, P. W., *1930*, Miocene Foraminifera from Buff Bay, Jamaica: *Jour. Paleontology*, vol. 4, no. 4, pp. 353–368, 3 pls.

——— and JARVIS, P. W., *1934*, Some interesting new uniserial Foraminifera from Trinidad: *Cushman Lab. Foram. Research, Contr.*, vol. 10, pt. 3, pp. 71–75.

——— and KLEINPELL, R. M., *1934*, New and unrecorded Foraminifera from the California Miocene: *Cushman Lab. Foram. Research, Contr.*, vol. 10, pt. 1, 23 pp., 4 pls.

——— and LAIMING, BORIS, *1931*, Miocene Foraminifera from Los Sauces Creek, Ventura County, Calif.: *Jour. Paleontology*, vol. 5, no. 2, pp. 79–120, 6 pls.

——— and PARKER, F. L., *1931*, Miocene Foraminifera from the Temblor of the east side of the San Joaquin Valley, California: *Cushman Lab. Foram. Research, Contr.*, vol. 7, pt. 1, 16 pp., 1 pl.

DORR, J. B., *1933*, New data on the correlation of the lower Oligocene of South and Central America with that of southern Mexico: *Jour. Paleontology*, vol. 7, no. 4, pp. 432–438.

GALLOWAY, J. J., and MORREY, MARGARET, *1929*, A Lower Tertiary foraminiferal fauna from Manta, Ecuador: *Bull. Am. Paleontology*, vol. 15, no. 55, 56 pp., 6 pls.

GUPPY, R. J. L., *1904*, *Geol. Mag.*, dec. 5, vol. 1, pp. 193–199, 241–250.

———, *1893*, The microzoa of the Tertiary and other rocks of Trinidad and the West Indies: *Field Naturalists' Club, Jour.*, pp. 277–290, December. Republished by G. D. Harris, *1921*, *Bull. Am. Paleontology*, vol. 8, no. 35, pp. 261–274.

HADLEY, W. H., *1934*, Some Tertiary Foraminifera from the north coast of Cuba: *Bull. Am. Paleontology*, vol. 20, no. 70A, 40 pp.

KLEINPELL, R. M., *1934*, Difficulty of using cartographic terminology in historical geology: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 18, no. 3, pp. 374–379.

KUGLER, H. G., *1936*, Summary digest of geology of Trinidad: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 20, pp. 1439–1453.

LEHNER, E., *1935*, Introduction a la geologie de Trinidad et bibliographie geologique: *Office nat. combust. liquides, Annales*, no. 4, pp. 691–730.

LIDDLE, R. A., *1928*, *The geology of Venezuela and Trinidad*, J. P. MacGowan, Fort Worth, Texas.

NATLAND, M. L., *1933*, The temperature and depth distribution of some recent and fossil Foraminifera in the southern California region: *Scripps Inst. Oceanography, Bull.*, vol. 3, no. 10, pp. 225–230.

NORTON, R. D., *1930*, Ecologic relations of some Foraminifera: *Scripps Inst. Oceanography, Bull.*, vol. 2, no. 9, pp. 331–388.

NUTTALL, W. L. F., *1928*, Tertiary Foraminifera from the Naparima region of Trinidad (British West Indies): *Geol. Soc. London, Quart. Jour.*, vol. 84, no. 333, pp. 57–115.

———, *1930*, Eocene Foraminifera from Mexico: *Jour. Paleontology*, vol. 4, no. 3, pp. 271–293, 3 pls.

———, *1932*, Lower Oligocene Foraminifera from Mexico: *Jour. Paleontology*, vol. 6, no. 1, pp. 3–35, 9 pls.

———, *1933*, Two species of *Miogypsina* from the Oligocene of Mexico: *Jour. Paleontology*, vol. 7, no. 2, pp. 175–177.

———, *1935*, Upper Eocene Foraminifera from Venezuela: *Jour. Paleontology*, vol. 9, no. 2, pp. 121–131, 2 pls.

PALMER, D. K., and BERMUDEZ, P. J., *1936*, Late Tertiary Foraminifera from the Matanzas Bay region, Cuba: *Soc. cubana hist. nat., Mem.*, vol. 9, no. 4, pp. 237–257.

PALMER, K VAN W., *1923*, Foraminifera and a

small molluscan fauna from Costa Rica: *Bull. Am. Paleontology*, vol. 10, no. 40, 18 pp., 2 pls.

PIJPERS, P. J., *1933*, Geology and paleontology of Bonaire (D.W.I.): *Geog. geol. Mededeel., Phys-Geol.*, Reeks no. 8, 97 pp.

RUTSCH, R., *1934*, Pteropoden und Heteropoden aus dem Miocaen von Trinidad (Brit. West Indies): *Eclogae geol. Helvetiae*, vol. 27, no. 2, pp. 299–326, 1 pl. Part II of Beitrage zur Kenntnis tropisch-amerikanischer Tertiar mollusken.

SCHENCK, H. G., *1928*, The biostratigraphic aspect of micropaleontology: *Jour. Paleontology*, vol. 2, pp. 158–165, 1 pl.

———, *1935*, What is the Vaqueros formation and is it Oligocene?: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 19, no. 4, pp. 521–536.

———, *1935a*, Nuculid pelecypods of the genus *Acila;* Part III of Beitrage zur Kenntnis tropisch-amerikanischer Tertiar mollusken: *Eclogae geol. Helvetiae*, vol. 28, no. 2, pp. 501–510.

———, and KLEINPELL, R. M., *1936*, Refugian stage of Pacific Coast Tertiary: *Am. Assoc. Petroleum Geologists, Bull.*, vol. 20, no. 2, pp. 215–255.

SENN, A., *1935*, Die stratigraphische Verbreitung der Tertiaren Orbitoiden mit spezieller Berucksichtigung ihres Vorkommens in Nord-Venezuela and Marokko: *Eclogae geol. Helvetiae*, vol. 28, no. 1, pp. 51–113, 369–373.

THALMANN, H. E., *1935*, Stratigraphisch wertvolle Foraminiferen im Tertiar des Coatzacoalcos-Beckens (Isthmus von Tehuantepec, Mexico): *Eclogae geol. Helvetiae*, vol. 28, no. 2, pp. 592–598.

———, *1935a*, Die miozane Tuxpan-Stufe im Gebiete zwischen Rio Tuxpan und Rio Tecolutla (Staat Veracruz, Ost-Mexico): *Eclogae geol. Helvetiae*, vol. 28, no. 2, pp. 543–546.

THORP, E. M., *1931*, Descriptions of deep-sea bottom samples from the western North Atlantic and the Caribbean Sea: *Scripps Inst. Oceanography, Bull.*, Tech. ser., vol. 3, no. 1, 31 pp.

TOLMACHOFF, I. P., *1934*, A Miocene microfauna and flora from the Atrato River, Colombia, South America: *Carnegie Mus., Annals*, vol. 23, pp. 275–356.

WILLIAMS, H. S., *1903*, Shifting of faunas as a problem of stratigraphic geology: *Geol. Soc. America, Bull.*, vol. 14, p. 185.

WOODRING, W. P., *1928*, Miocene mollusks from Bowden, Jamaica; Part II, Gastropods and discussion of results: *Carnegie Inst. Washington, Pub.* 385, 564 pp.

H. D. HEDBERG, GEOL. LAB., MENE GRANDE OIL COMPANY, APARTADO 35, CIUDAD BOLIVAR, VENEZUELA. MANUSCRIPT RECEIVED BY THE EDITOR, APRIL 24, 1937.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 8, PP. 698–705, PL. 93,
TEXT FIGS. 1–4, DECEMBER, 1937

THE FUSULINID, *WEDEKINDELLINA*, IN MID-PENNSYLVANIAN ROCKS OF KANSAS AND MISSOURI

NORMAN D. NEWELL AND RAYMOND P. KEROHER

ABSTRACT

A new species of *Wedekindellina* is described from the lower part of the Missouri subseries (Bethany Falls limestone). This is the first record of the genus in rocks of post-Des Moines age in America, *Wedekindellina* having been generally regarded as an index to Cherokee age (early Des Moines). Certain peculiarities of the new species, particularly the large size of the proloculum, are regarded as the products of evolutionary modification, possibly furnishing a key to evaluation of characters found in other related species. Close similarity of the new species with the Russian *Wedekindellina uralica longa* (Doutkevitch) suggests, as an approximation, a correlation of the Bethany Falls limestone with uppermost Moscovian as defined by Doutkevitch in the Urals.

The genus *Wedekindellina* was established by Dunbar and Henbest (1933) for lower Pennsylvanian species of fusulinids having a fusulinelloid wall structure, relatively plane septa, slender form, and heavy secondary deposits in the axial region.

Eight species and two varieties of *Wedekindellina* have been described from American Pennsylvanian rocks. All of these appear to be of Cherokee (lower Des Moines) age. Known occurrences in Russia (Doutkevitch, 1934; Semichatov, 1935; Rauser, 1935, 1936) and China (Lee, 1927; Thompson, 1934) are apparently also of Des Moines (Moscovian) age. The Russian wedekindellinas, however, probably are younger than Cherokee, being found only in upper Moscovian beds. The widespread occurrence of species of this genus in rocks of Des Moines age seemingly has justified the general acceptance of *Wedekindellina* as an indicator of early Pennsylvanian age.

During current studies on mid-Pennsylvanian (Missourian) fusulinid faunas we have discovered a widespread, but thin zone of *Wedekindellina* in the lower part of the Bethany Falls limestone member of the Swope formation, 150 feet above the Cherokee shale, far above the previously known range of the genus in America.

Doutkevitch (1934) has described a *Wedekindellina* under the name *Fusulinella uralica* from a deep boring on the western slope of the middle Urals in Verkhne-Chussovskye Gorodki, Russia. The species, and associated *Fusulinella librovitchi* Doutkevitch, were taken from a limestone core a few feet below the top of the Moscovian series as interpreted by Doutkevitch.[1] *Wedekindellina uralica* and its varieties *longa* and *inflata* (Doutkevitch) are remarkable for their relatively large proloculum and widely flaring tunnel angle. The va-

[1] Dr. Carl O. Dunbar has indicated to us an opinion that the lower part of the beds overlying the *Wedekindellina* horizon should also be classed as Moscovian, because these beds contain *Fusiella*, *Fusulinella*, and several species of *Staffella*.

riety *longa* is like the form from the Bethany Falls limestone, being closely similar in size of proloculum, tunnel, shell size, proportions, and number of volutions. The only noteworthy difference between the two, discernible from Doutkevitch's description, lies in the slightly larger number of septa and more regular growth in the Russian form. The Bethany Falls species is much more closely allied to the Russian form than to any American *Wedekindellina* thus far described.

The species *W. uralica* has also been illustrated from late Moscovian beds of Petschora province along the river Podcheren on the west slope of the northern Urals (Rauser-Černoussova, Beljaew, and Reitlinger, 1936, fig. 5, pl. 2), where it is associated with *Wedekindellina dutkewitchi* Rauser and Beljaew. The latter species apparently is quite different from *uralica*, and therefore unlike our *W. ultimata*. Descriptions of *W. dutkewitchi* have not been available to us; therefore, a detailed comparison is not possible at the present time.

In the region of the Samara bend of Volga River in Russia, some 500 miles southwest of Doutkevitch's area, 100 feet of "*Wedekindellina* beds" overlie strata "with Fusulinidae of the Moscovian type" and are overlain in succession by beds containing *Triticites* and *Quasifusulina longissima* (see Semichatov, 1935). The intervening beds with *Wedekindellina* and *Fusulinella bocki* do not contain the typical Moscovian brachiopod fauna of the underlying rocks, and apparently belong to a

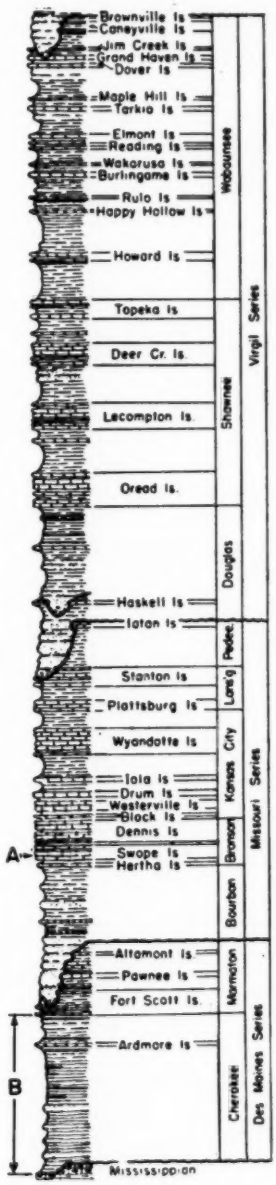


FIG. 1.—Graphic section of the Pennsylvanian rocks in Kansas and Missouri, showing the normal range of *Wedekindellina* (B), and the newly discovered occurrence in the Bethany Falls limestone member of the Swope formation (A).

younger division than the uppermost Moscovian of the Moscow region. Accumulating evidence seems to indicate that the Russian wedekindellinas thus far known are no older than uppermost Moscovian (late Des Moines). Rauser (1936) appears to substantiate this conclusion by indicating an upper Moscovian range for the genus.

Because of the close similarity between our Bethany Falls species and the late Moscovian *Wedekindellina uralica longa* (Doutkevitch), and because of the relative lateness of both forms, it seems that an approximate age of uppermost Moscovian is indicated for the Bethany Falls limestone. Most American investigators hold that the upper limit of the Des Moines subseries is equivalent to the top of the Moscovian. It appears possible, however, that the upper Moscovian beds in some of the Russian sections may be slightly younger than the American Des Moines subseries.

The variable character of the secondary axial deposit and the nearly plane septa characteristic of *Wedekindellina* render difficult the differentiation of species in this genus. Statistical data on described species are generally incomplete. Nevertheless, examination of large suites of material has convinced us that statistical study permits fine differentiation that would not be possible with a small number of specimens. A resurvey of some of the previously described species is desirable and should be based on more complete collections.

Acknowledgment is made to the Graduate Research Committee at the University of Kansas for funds used in preparing the thin sections used in this study.

SYSTEMATIC DESCRIPTION

Family FUSULINIDAE Möller

Genus WEDEKINDELLINA Dunbar and Henbest

WEDEKINDELLINA ULTIMATA Newell and Keroher, n. sp.

Plate 93, figures 1*a*–9

Test relatively large for the genus, attaining, in rare gerontic individuals of eight volutions, an extreme axial dimension of 4.80 mm. and a sagittal length of 1.52 mm., more commonly measuring 3 to 4 mm. along the axis and 0.8 to 1.0 mm. in sagittal length, with an average form ratio of 3.48 in mature specimens of six volutions; form slender, acutely

Shell measurements in Wedekindellina ultimata[a]

Volution	Axial dimension in mm.		Sagittal dimension in mm.	
	Minimum	Maximum	Minimum	Maximum
8	4.32	4.80	1.28	1.52
7	2.92	4.32	0.96	1.16
6	2.48	3.68	0.72	1.12
5	1.76	2.56	0.60	0.80
4	1.12	1.64	0.40	0.56
3	0.72	1.04	0.28	0.36
2	0.36	0.64	0.16	0.24
1	0.16	0.40	0.12	0.16

[a] Based on twenty axial sections of specimens mainly having six volutions.

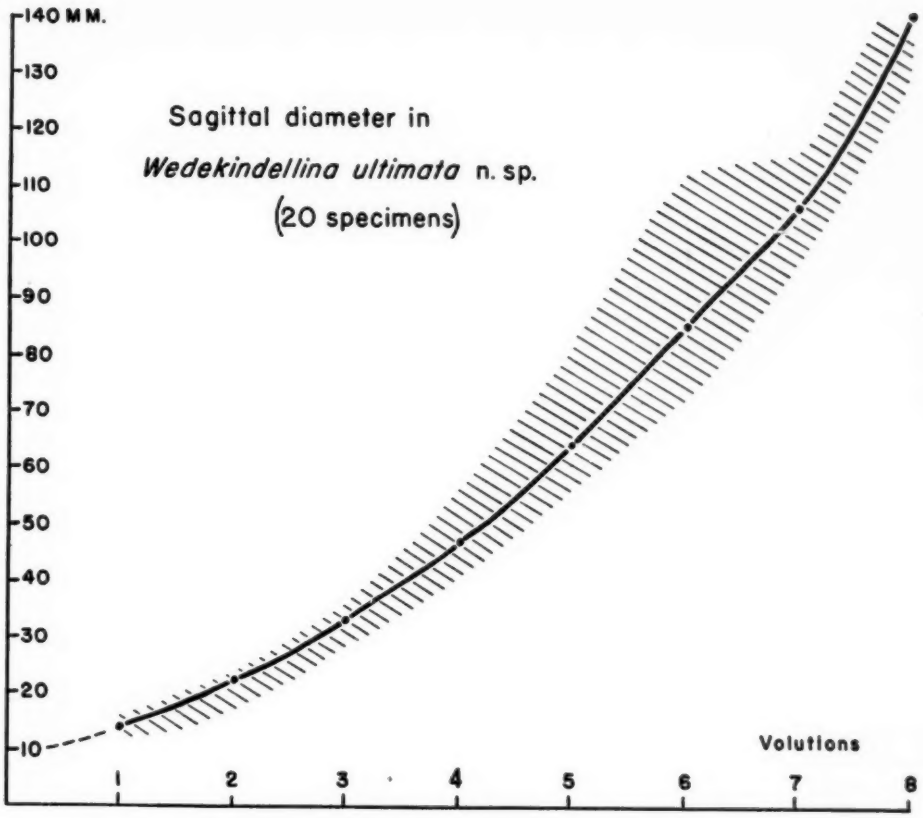


FIG. 2.—Curve indicating the rate in change of the sagittal diameter with the addition of successive volutions.

fusiform, becoming irregular in growth toward the poles; septa nearly, but not quite, plane across the middle half, becoming faintly fluted toward the poles, devoid of observed septal pores; wall fusulinelloid, distinguished by a relatively thick diaphanotheca, which measures about 12 to 14 microns in the sev-

Table of size, form ratio, and number of volutions in American wedekindellinas

Species	Form ratio	No. volutions	Length[a]
W. euthysepta (Henbest)	3.90	9	4 mm.
W. henbesti (Skinner)	3.85	10	5
W. dunbari Thompson	3.70	8	3
W. minuta (Henbest)	3.50	6	2
W. ultimata Newell and Keroher, n. sp.	3.48	6	3
W. elfina Thompson	3.40	8	2
W. excentrica (Roth and Skinner)	2.90	9	4
W. uniformis Thompson	2.85	8	2
W. coloradoensis perforata (Roth and Skinner)	2.70	9	4
W. coloradoensis (Roth and Skinner)	2.65	9	4
W. excentrica magna (Roth and Skinner)	2.58	13	5

[a] Approximate axial length.

enth volution and 6 to 8 microns in the sixth volution; a relatively thin inner tectorium, ranging in mature volutions from 3 or 4 microns across "roofs" of chambers to 10 microns on the front and back surfaces of the septa; outer tectorium obsolescent after the sixth volution, but moderately well developed in earlier volutions, where it thickens laterally toward the poles, beyond the chomata, tending to a moderate degree to fill the chambers along an axial zone of the shell, measuring, across the tunnel, together with a negligible thickness of tectum, about 9 microns in the sixth volution, and 7 microns in the seventh volution; chomata well developed, abrupt, fusing laterally and generally imperceptibly with the axial deposits of outer tectorium, which deposits overlap the chomata from the polar regions; septal count fairly distinctive, observations on twenty sagittal sections being given in the table below; tunnel irregular and angle variable, generally measuring, however, 15 to 20 degrees in the first four volutions, flaring from 25 to 40 degrees in the sixth volution; proloculum extraordinarily large for the genus, ranging from 88 to 100 microns in diameter in thirty specimens.

Septal count in twenty specimens of Wedekindellina ultimata, *Newell and Keroher n. sp.*

Volution	1	2	3	4	5	6	7	8
Minimum	8	12	13	17	17	20	23	26
Maximum	11	17	19	23	26	27	27	27
Average	9	13	17	19	21	23	25	26

Discussion.—Wedekindellina ultimata

Proloculum measurements of Wedekindellina ultimata *and other American species*

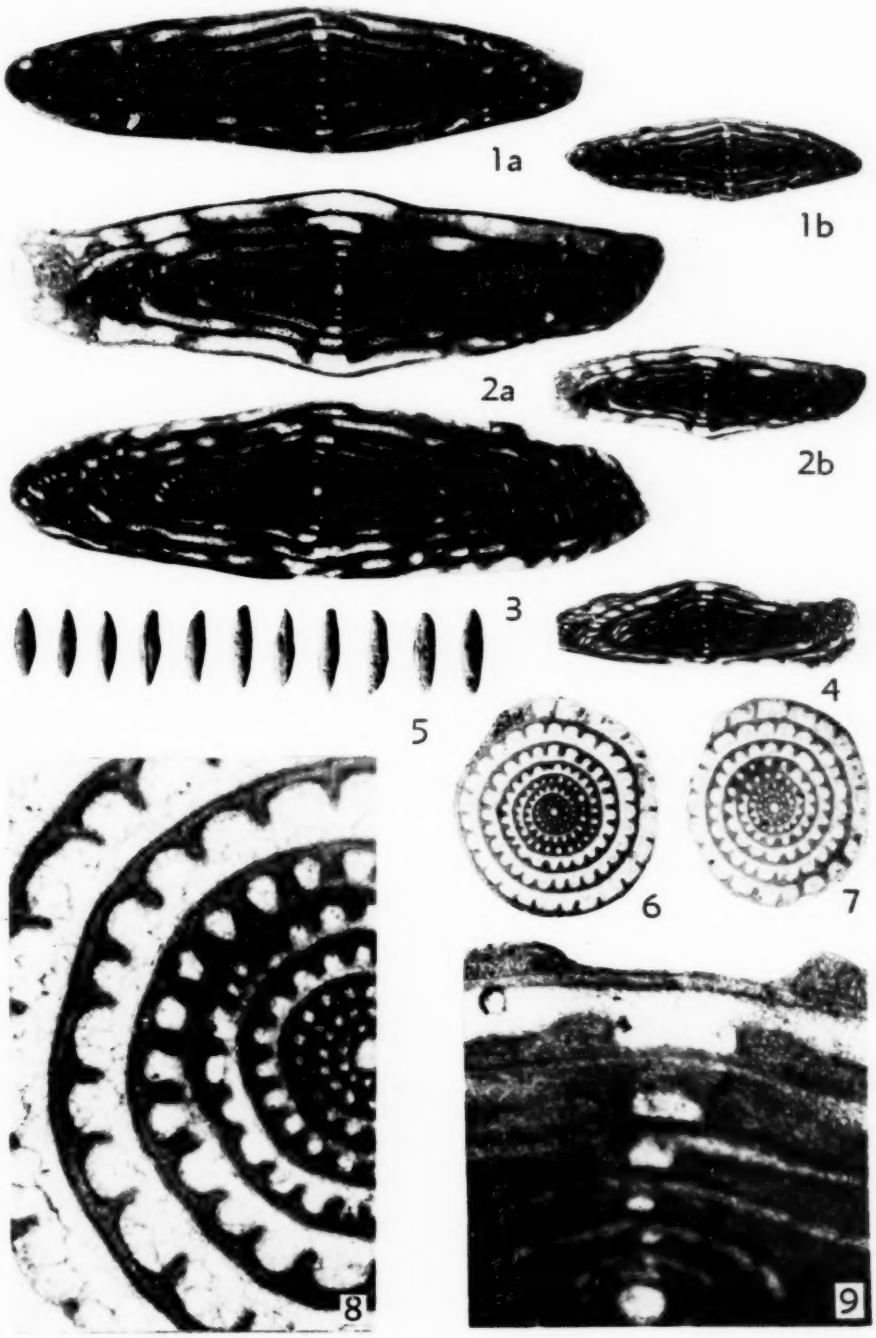
Species	Minimum diameter	Maximum diameter
Wedekindellina ultimata Newell and Keroher, n. sp.	88 microns	100 microns
W. henbesti (Skinner)	72	91
W. coloradoensis (Roth and Skinner)	69	94
W. excentrica (Roth and Skinner)	46	84
W. minuta (Henbest)	42	61
W. coloradoensis perforata (Roth and Skinner)	41	77
W. uniformis Thompson	35	40
W. dunbari Thompson	35	35
W. excentrica magna (Roth and Skinner)	34	63
W. euthysepta (Henbest)	30	45
W. elfina Thompson	30	50

EXPLANATION OF PLATE 93

(All specimens from the Bethany Falls limestone, near Kansas City.)

FIGS. *1a–9—Wedekindellina ultimata* Newell and Keroher, n. sp. *1a, b*, Axial section of a paratype, having a relatively narrow tunnel and exceptionally heavy axial deposit, ×20, and ×10, Kansas Univ., no. 239.11. *2a, b*, Axial section of the holotype, showing normal characters of the species except for an exceptionally symmetrical tunnel, ×20, and ×10, Kansas Univ., no. 239.17. *3*, Axial section of a paratype, showing the normal irregularity of the tunnel, ×20, Kansas Univ., no. 239.14. *4*, Axial section of a paratype having a particularly weak development of the secondary axial filling, ×10, Kansas Univ., no. 239.15. *5*, A series of adult specimens, paratypes, showing the form and irregular growth of the species, ×3, Kansas Univ., no. 239. *6*, Sagittal section of a paratype, ×20, Kansas Univ., no. 239.11. *7*, Sagittal section of a paratype, ×20, Kansas Univ., no. 239.13. *8*, Part of a sagittal section of a paratype, showing the relatively thick diaphanotheca, obsolescent outer tectorium, thin tectum, and variable inner tectorium, ×75, Kansas Univ., no. 239.12. *9*, Part of an axial section of a paratype showing wall structure, ×75, Kansas Univ., no. 239.

(p. 700)



Newell and Keroher, Pennsylvanian Fusulinids

UNIV. OF MICH.

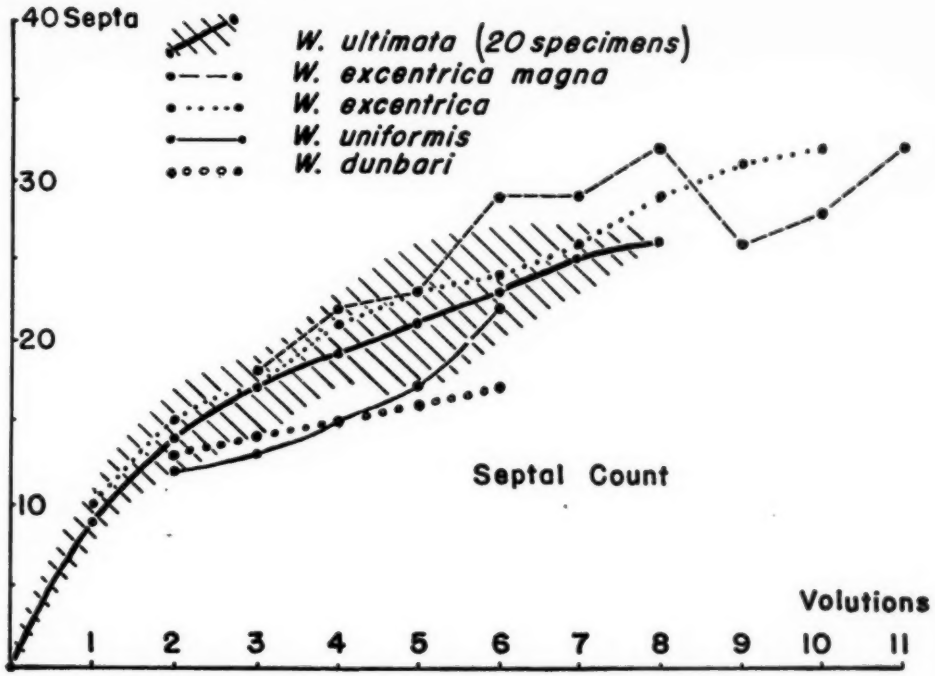


FIG. 3.—Graphic curves showing the comparative rate of addition of septa in *Wedekindellina ultimata* Newell and Keroher, n. sp., and certain other species.

is one of the youngest species of the genus. Certainly no other post-Des Moines wedekindellinas have thus far been recorded in North America.

The discovery of this form in the Bethany Falls limestone raised question regarding the proper stratigraphic classification of that formation. A careful search in our fusulinid material from the Bethany Falls limestone revealed a few poor specimens of a *Triticites* associated intimately with *Wedekindellina*. The *Triticites* is too fragmentary for specific identification. In spite of the occurrence of *Wedekindellina* in the Bethany Falls limestone, an imposing array of diastrophic and faunal evidence (Moore, 1936) can leave no question that this limestone belongs in the post-Des Moines beds now classified as a separate unit, the Missouri subseries.

The new species is quite distinct from other American wedekindellinas. Its

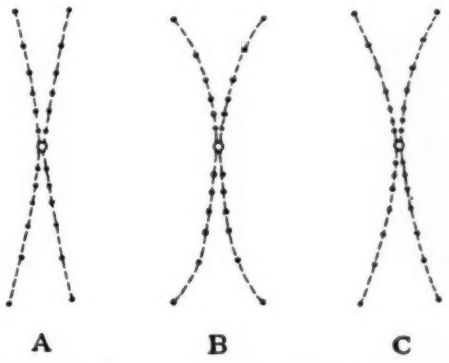


FIG. 4.—Diagrammatic representation of tunnel angle in *Wedekindellina ultimata*, showing range of variation in ten specimens; A and B representing less common variations and C the ordinary condition. These diagrams were reconstructed from irregular tunnels in individual specimens so as to be directly comparable. Such symmetrical reconstruction is recommended for fusulinid species having irregular tunnels.

unique stratigraphic position high above the nearest relatives suggests that the differences noted in this form are the cumulative result of evolutionary modification. These distinctions may serve as a key for future evaluation of specific characters in the genus *Wedekindellina*.

Most notable of the distinctive characters in the new species is the relatively large proloculum, which is larger than that of any other American species. The proloculum in most species of *Wedekindellina* is ellipsoidal, so that an approximation of its dimensions cannot be obtained without a large number of observations. Because of this fact, the measurements for some of the previously described species may be subject to significant revision. The secondary axial deposit is less well developed than is common in the genus, and the diaphanotheca is relatively thicker than that of any other *Wedekindellina* known to us. In general, the tunnel in our species appears to flare more markedly than in other American species, but direct comparison is impossible until the tunnels are diagrammatically reconstructed so as to be bilaterally symmetrical. The septal count in our species produces a graphic curve that will readily distinguish it from *Wedekindellina uniformis*, *W. coloradoensis*, *W. dunbari*, *W. excentrica*, and *W. excentrica magna*, but data are too incomplete to distinguish our form from other American species on this single character. The form ratio of *W. ultimata* is different from published ratios for other species, but is not outstandingly distinctive.

The new species is notably like *Wedekindellina uralica longa* (Doutkevitch) from the western slope of the middle Urals. The following table indicates the close similarity of the two species in certain features.

The most outstanding differences between the two forms lie in the greater number of septa per volution, and greater regularity of growth in the Russian form. However, the discrepancy in septal count may be more apparent than real. The septal count given above for the Russian fusulinid was stated for *Wedekindellina uralica* s.s. It may be that the variety *longa* is not so closely related to the typical form as Doutkevitch supposed. He did not give the septal count for the variety *longa*.

Comparison of Wedekindellina ultimata *and* W. uralica longa

	W. uralica longa	*W. ultimata*
Axial length	2.76 to 3.59 mm.	2.48 to 3.68 mm. (6 vol.)
Sagittal width	0.79 to 0.93 mm.	0.72 to 1.12 mm. (6 vol.)
Form ratio	3.3 to 3.9	3.48
Tunnel angle	34 to 45 degrees	25 to 40 degrees
No. volutions	6 to 6.5	6 to 8 (mainly 6)
Proloculum	90 microns	88 to 100 microns
Wall thickness	20 microns (6.5 vol.)	20 microns (6 vol.)
Septal count	first vol.[a]—10	first vol.— 9
	second vol.[a]—16	second vol.—13
	third vol.[a]—22	third vol.—17
	fourth vol.[a]—23	fourth vol.—19
	fifth vol.[a]—29	fifth vol.—21

[a] Given for *Wedekindellina uralica* s.s.; the variety *longa* may differ.

Occurrence.—Observations in Bourbon and Miami counties, Kan., and Jackson County, Mo., indicate that *Wedekindellina ultimata* is very widely distributed in eastern Kansas and northwestern Missouri in a thin zone ranging from 1 to 6 feet above the base of the Bethany Falls limestone of the Swope formation. Our type collections, numbering several hundreds of specimens, came from a small and very old abandoned quarry, 75 yards west of the intersection of highway 40 and 4-E in the SE. ¼ SW. ¼ sec.

17, T. 49 N., R. 32 W., Jackson County, Mo. Another smaller collection came from natural exposures on the east side of highway 13-S at a concrete culvert near the SW. cor. NE. ¼ sec. 16, T. 47 N., R. 33 W., Jackson County, Mo.

Type collections, Kansas Univ., no. 239.

REFERENCES

DOUTKEVITCH, G. A., *1934*, Some new species of Fusulinidae from the Upper and Middle Carboniferous of Verkhne-Chussovskye Gorodki on the Chussovaya River (western slope of the Middle Ural): *Oil. Geol. Inst., Trans.*, ser. A, vol. 36, pp. 1–95, pls. 1–6.

DUNBAR, C. O., and HENBEST, L. G., *1933*, in Cushman, J. A., Foraminifera: *Cushman Lab. Foram. Research, Special Pub.* 4, p. 134.

HENBEST, L. G., *1928*, Fusulinellas from the Stonefort limestone member of the Tradewater formation: *Jour. Paleontology*, vol. 2, pp. 70–85, pls. 8–10.

LEE, J. S., *1927*, Fusulinidae of north China: *Paleontologia Sinica*, ser. B, vol. 4, fasc. 1, p. 12.

MOORE, RAYMOND C., *1936*, Stratigraphic classification of the Pennsylvanian rocks of Kansas: *Kansas Geol. Survey, Bull.* 22, pp. 51–88.

RAUSER-ČERNOUSSOVA, D., *1935*, Bemerkungen über die Gattung *Wedekindellina* Dunbar et Henbest und ihre Stratigraphische Bedeutung: *Acad. sci. U.R.S.S., Comptes rendus*, vol. 4 (9), pp. 117–120.

———, *1936*, Zur Frage von der Stratigraphischen Bedeutung der Ober-Pälaozoischen Foraminiferen: *Acad. sci. U.R.S.S., Bull.* 1. pp. 61–86.

RAUSER-ČERNOUSSOVA, D., BELJAEW, G., and REITLINGER, D., *1936*, Die Ober-Pälaozoischen Foraminiferen aus dem Petschoralande (der Westabhang der Nord-Urals): *Acad. sci. U.R.S.S., Trans. Com. Polar Regions*, fasc. 28.

ROTH, ROBERT, and SKINNER, JOHN, *1930*, The fauna of the McCoy formation: *Jour. Paleontology*, vol. 4, pp. 332–352, pls. 28–31.

SEMICHATOV, S. V., *1935*, The Middle Carboniferous of Russia: *Geol. Mag.*, vol. 72, pp. 433–441.

SKINNER, JOHN, *1931*, Primitive fusulinids of the Mid-Continent region: *Jour. Paleontology*, vol. 5, pp. 253–259, pl. 30.

THOMPSON, M. L., *1934*, The fusulinids of the Des Moines series of Iowa: *Iowa Univ. Studies*, vol. 16, pp. 278–332, pls. 20–23.

NORMAN D. NEWELL, UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN. RAYMOND P. KEROHER, STATE GEOLOGICAL SURVEY, LAWRENCE, KANSAS. MANUSCRIPT RECEIVED BY THE EDITOR, APRIL 26, 1937.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 8, PP. 706–708, TEXT FIGS. 1, 2, DECEMBER, 1937

NEW OCCURRENCE OF THE UPPER CARBONIFEROUS CRINOID GENERA *AMPHICRINUS* AND *SYNEROCRINUS*

L. R. LAUDON

ABSTRACT

Two species, representing one of the latest occurrences of the flexible crinoids, have recently been discovered in the lower portion of the Upper Carboniferous rocks of Oklahoma. One is a new species of *Synerocrinus*, heretofore known only from the Carboniferous rocks of Russia and Scotland. The other, represented by two specimens, is *Amphicrinus carbonarius* originally described from fragmentary material by Springer. The new specimens allow a much more complete elucidation of its characters.

Upper Carboniferous flexible crinoids occur only rarely in any section. The discovery of a new species of *Synerocrinus* and two specimens of the hitherto partially known *Amphicrinus carbonarius* is rather unusual.

I am indebted to Mr. Fred Bush of Tulsa for the specimen of *Synerocrinus* and Mr. Bob Stevens of Tulsa who collected one of the specimens of *Amphicrinus*.

SYSTEMATIC DESCRIPTIONS

Order FLEXIBILIA Zittel

Family ICHTHYOCRINIDAE Angelin (Emend. Wachsmuth and Springer)

Genus SYNEROCRINUS Jaekel, 1897

SYNEROCRINUS FARISHI Laudon, n. sp.

Figure 2

Synerocrinus incurvus, the genotype and only known species, was originally described as *Forbesiocrinus* by Trautschold (1867). Because of its peculiar heterotomous arm structure, Jaekel (1898) in 1897 introduced the genus *Synerocrinus* as a member of the Taxocrinidae. On the basis of careful dissection, Springer (1920) demonstrated that while the genus exhibits characteristics of both the Taxocrinidae and the Ichthyocrinidae, its fundamental characters belong definitely with the latter.

S. farishi is a large species, measuring over 120 mm. from base to arm tips. It is represented by a single damaged specimen, in which the plates of the base and anal side are largely missing. Three rays, the anterior and the two antero-lateral, are preserved down to tops of the radials. Ibr 14 mm. in width, height 9 mm. Ibr_2 axillary, width 20 mm., height 11 mm. IIBr, 16 mm. in width, height 9 mm. $IIBr_2$ hexagonal, width 12 mm., height 9 mm. $IIBr_3$ axillary, pentagonal, width 14 mm., height 11 mm. First three IIIBr taper rapidly; 13, 11, and 9 mm. in width respectively. Sinuate median lobe well developed. Remaining Br robust, strongly arched, tapering little, sutures deeply intrenched. Strong rammule like branches given off alternately, width approximately equal to height of brachial at point of origin. Primary iBr, heptagonal, much smaller than Br, supporting three small plates in second series, followed by several series of small irregular plates. Primary iIIBr heptagonal, height 8 mm., width 8 mm., followed by three small irregular plates in the second cycle and several smaller irregular plates. Three small iIIIBr.

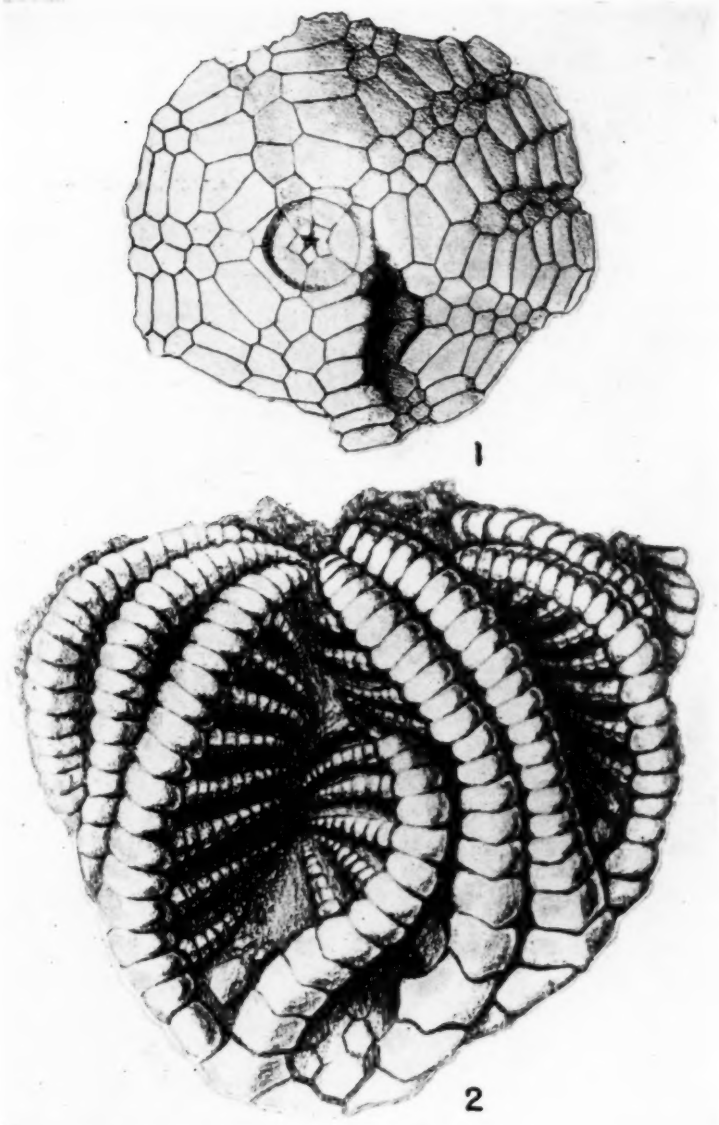


FIG. *1—Amphicrinus carbonarius* Springer. Basal view of specimen from Oologah limestone near Tulsa, Okla., showing character of base and anal series, ×1. (p. 708)
2—Synerocrinus farishi Laudon, n. sp. Anterior view of holotype, ×1. (p. 706)

Relationships.—This new species is easily distinguishable from *S. incurvus* by its large size, heavy arms with depressed sutures, and larger number of interbrachial plates.

Occurrence.—Bendian series of the Carboniferous system. Bostwick conglomerate, 300 feet above the Otterville limestone, SE. ¼ SW. ¼ SE. ¼, sec. 9, T. 6 S., R. 2 E., Ardmore Basin, Okla.

Collected by Mr. Linn Farish, of the Sinclair Prairie Oil Company. The species is named in honor of Mr. Farish.

Types.—University of Tulsa.

Genus AMPHICRINUS Springer, 1906

AMPHICRINUS CARBONARIUS Springer

Figure 1

Amphicrinus carbonarius SPRINGER, *1920*, Smithsonian Inst., Pub. 2501, p. 341, pl. 60, figs. 12*a*, *b*.

Amphicrinus carbonarius was originally described by Springer from a single flattened specimen in which much of the base and anal structures were missing. The arms on one side are excellently preserved. Two specimens that are referred to this species have been found recently near Tulsa. Since the arms are missing on both of the Tulsa specimens, the holotype is very valuable, although incomplete. It is not possible to determine whether the Tulsa specimens are identical with the original because of the fragmentary condition of the holotype. Since both occur in approximately the same stratigraphic position and since the parts check rather closely, a new specific name is not being proposed for the Tulsa specimens.

Calyx shallow, expanding rapidly, height 12 mm. to top of $IIIBr_3$, width at this point 42 mm. BB and parts of RR in depression occupied by proximal columnal. BB small except posterior which extends out beyond basal circlet. RR protruding slightly beyond columnal depression, hexagonal except two posterior which are pentagonal. IBr_1 hexagonal, larger than RR, width 8 mm., height 4 mm. IBr_2 hexagonal or pentagonal, axillary, slightly wider than RR. $IIBr_1$ usually hexagonal, occasionally heptagonal, variable in size, wider than high, usually smaller than IBr. $IIBr_2$ hexagonal or pentagonal, width twice height, same size as $IIBr_1$. $IIBr_3$ pentagonal to heptagonal, axillary, approximately size of $IIBr_2$. IIIBr at least three, width averages twice height. iBr_1 hexagonal, height 5 mm., width 4 mm., followed by a slightly depressed double row of iBr variable in size and shape. $iIIBr_1$ hexagonal or heptagonal, followed by a double row of small plates of which seven are preserved in one specimen. Posterior B heptagonal, greatly elongated, truncated for support of X which lies in iRr position. X larger than iBr_1, hexagonal, followed by two single supplementary X plates which are apparently followed by a double row of plates. X interradius smaller than iBr interradii. Degenerate X character shown in *A. scoticus* not present. Plates, smooth, undecorated, and very thin.

Relationships.—This species is distinguishable from *A. scoticus*, the only other species, in that *A. scoticus* has a single row of anal plates, while *A. carbonarius* has a double row after the second supplementary piece. *A. carbonarius* appears to be slightly larger in general proportions.

Occurrence.—Oologah limestone, Garnett Quarry, 7 miles northeast of Tulsa, Okla.

Figured specimen.—University of Tulsa.

REFERENCES

JAEKEL, O., *1898*, *Deutsche. geol. Gesell., Zeitschr.*, vol. 49, for 1897, p. 47.

SPRINGER, F., *1920*, Crinoidea Flexibilia: *Smithsonian Inst., Pub.* 2501, p. 335, pl. 42, figs. 1–9, and pl. 75, figs. 12, 13.

TRAUTSCHOLD, H., *1867*, *Soc. Imp. Moscow, Bull.*, vol. 40, no. 3, p. 31, pl. 4, figs. 4, 5*a*, *b*, and text diagram.

L. R. LAUDON, UNIVERSITY OF TULSA, TULSA, OKLAHOMA. MANUSCRIPT RECEIVED BY THE EDITOR, MARCH 1, 1937.

JOURNAL OF PALEONTOLOGY, VOL. 11, NO. 8, PP. 709–714, DECEMBER, 1937

GENOTYPE DESIGNATIONS AND NEW NAMES FOR INVALID HOMONYMS AMONG PALEOZOIC GASTROPOD GENERA

J. BROOKES KNIGHT

ABSTRACT

Genotypes are designated for 21 genera of Paleozoic Gastropoda for which genotypes had not previously been fixed. A list of 21 generic names that are invalid because of homonymy is given, 6 of these being replaced by new names, as follows: *Anastrophina* Perner, MS. (for *Staurospira* Perner, 1907, *not* Haekel, 1887); *Beraunia* Perner, MS. (for *Cyclotropis* Perner, 1903, *not* Tapp. Canefri, 1883); *Burdikinia* Knight (for *Polyamma* Etheridge, Jr., 1917, *not* Kriechbaumer, 1894); *Episfaxis* Perner, MS. (for *Cosmina* Perner, 1919, *not* Robineau-Desvoidy, 1830); *Littorinides* Knight (for *Rhabdopleura* de Koninck, 1881, *not* Allman, 1869); *Sosiospira* Knight (for *Platychilus* Gemmellaro, 1889, *not* Cossmann, 1888, or others).

For a number of years I have been engaged in an intensive study of the genotype species of every generic name proposed for Paleozoic gastropods. In every case possible, this study has been based on the type specimens of the genotype species. In the case of some generic names for which no genotype species had been validly selected, it was necessary to choose a genolectotype from among the genosyntypes, and to base the study on the type specimens of the species so chosen. In making the choice, very careful consideration was given to many characters often available only to one working with the type specimens. For this reason, and because not inconsiderable expense[1] has been incurred in visiting museums at home and abroad, it is thought best to fix these genotype selections by publishing them.

The generic names for which no valid genotype appears hitherto to have been named are given, p. 710. The date of proposal of each generic or specific name, which is also a key to the appended list of references, is followed at least once with the pertinent page reference in parenthesis. The genotype species are all given under the generic and specific combinations used when they were originally described, which does not necessarily include the generic name for which the species serves as genotype.

During the course of the work, certain generic names proposed for Paleozoic Gastropoda were found to be unreplaced homonyms. At present, I know of some 21 unreplaced homonyms among the 500 generic names proposed for Paleozoic gastropods. After careful study, it seems advisable to replace 6 of them at this time. One will be replaced by its original author; the International Commission on Zoological Nomenclature is being petitioned to save one; and it is suggested that 13 of them be allowed to lapse, either because close subjective synonyms make new names unnecessary, or because the species on which the names are founded are so

[1] Expenses largely defrayed by a grant from the Penrose Fund of the Geological Society of America.

Designation of Genotype Species for Certain Genera

Generic name.	Genotype species, here designated.
Antitrochus Whidborne, 1891 (p. 234)...	*Antitrochus arietinus* Whidborne, 1891 (p. 235).
Calloconus Perner, 1903 (p. 41).....	*Pleurotomaria* (*Calloconus*) *humilis* Barrande, MS., Perner, 1903 (p. 48).
Cyrtodiscus Perner, 1903 (p. 74).....	*Oxydiscus* (*Cyrtodiscus*) *procer* Barrande, MS., Perner, 1903 (p. 74).
Euconospira Ulrich, 1897 (p. 955).....	*Pleurotomaria turbiniformis* Meek and Worthen, 1861 (p. 461).
Hesperiella Holzapfel, 1889 (p. 54).....	*Pleurotomaria contraria* de Koninck, 1843 (p. 401).
Holopella M'Coy, 1851 (p. 47).....	*Holopella gracilior* M'Coy, 1851 (p. 47).
Hypodema de Koninck, 1853 (p. 140)...	*Calceola dumontiana* de Koninck, 1843 (p. 312).
Matherellina Kobayashi, here validated[2].	*Matherella walcotti* Kobayashi, 1933 (p. 261).
Michelia Roemer, 1854 (p. 73).....	*Michelia cylindrica* Roemer, 1854 (p. 73).
Mimospira Koken, 1925 (p. 235).....	*Onychochilus helmhackeri* Barrande, MS., Perner, 1900 (pp. 4, 14).
Palaeomphalus Koken, 1925 (p. 121)....	*Euomphalus gradatus* Koken, 1896 (p. 398).
Pedasiola Spriesterbach, 1919 (p. 496)..	*Pedasiola rhenana* Spriesterbach, 1919 (p. 498).
Pileolus Spriesterbach, 1919 (p. 501), not *Pileolus* Cookson, MS., Sowerby, 1823, or Lesson, 1831, or Ehrenberg, 1843...	*Pileolus obliquus* Spriesterbach, 1919 (p. 503).
Platychilus [*Platycheilus*] Gemmellaro, 1889 (p. 139), not *Platychilus* Cossmann, 1888, or Jakowlew, 1874.....	*Platychilus canaliculatum* Gemmellaro, 1889 (p. 140).
Plocostoma Gemmellaro, 1889 (p. 168)...	*Pleurotomaria* (*Plocostoma*) *neumayri* Gemmellaro, 1889 (p. 170).
Prosoptychus Perner, 1903 (p. 141).....	*Bellerophon* (*Prosoptychus*) *plebeius* Barrande, MS., Perner, 1903 (p. 141).
Rhabdospira Perner, 1903 (expl. pl. 75), not *Rhabdospira* Donald, 1898.....	*Rhabdospira bifrons* Barrande, MS., Perner, 1903 (expl. pl. 75).
Staurospira Perner, 1907 (p. 304), not *Staurospira* Haekel, 1887.....	*Holopea vermiculosa* Barrande, MS., Perner, 1903 (expl. pl. 63).
Temnospira Perner, 1903 (expl. pl. 79)..	*Brochidium* (*Temnospira*) *monile* Barrande, MS., Perner, 1903 (expl. pl. 80).
Tortilla Perner, 1903 (expl. pl. 59).....	*Tortilla disjuncta* Barrande, MS., Perner, 1903 (expl. pl. 59).
Turbonellina de Koninck, 1881 (p. 76)...	*Trochus lepidus* de Koninck, 1843 (p. 450).

[2] Kobayashi in 1933 (p. 262) proposed the name *Matherellina* "provisionally" for three species, including *Matherella walcotti*, which he described as new. Although the practice of proposing names for provisional generic groups has little to recommend it, the name would have been valid in a technical sense if the author had complied with the provisions of Article 25 of the International Rules of Zoological Nomenclature, as amended at the Congress at Budapest in 1927, in respect to designating a genotype. Article 25, as amended, provides that no generic name proposed after December 31, 1930 "shall have any status of availability (hence also, of validity) under the rules, unless and until it is published . . . with the definite unambiguous designation of a type species." Kobayashi failed to designate a genotype, and hence the name, as published by him in 1933, is unavailable and invalid. Doctor Kobayashi has requested me to validate it by naming *Matherella walcotti* Kobayashi as genotype. The name, now validated for the first time, must date from the present publication.

inadequately known that any genera founded on them are useless and confusing.

NAMES PROPOSED FOR PREOCCUPIED NAMES

The following names are here replaced: *Anastrophina* Perner, MS.,[3] new name for, and objective synonym of *Stauro-*

[3] While in Prague, in 1934, I advised Professor Perner that certain of his generic names were unreplaced invalid homonyms. He then was kind enough to furnish the manuscript names employed here, and thus shares in the responsibility of proposing them.

spira Perner, 1907 (p. 304), invalid homonym of *Staurospira* Haekel, 1887. Genotype *Holopea vermiculosa* Barrande, MS., Perner, 1903 (expl. pl. 63) and 1907 (p. 305).

Beraunia Perner MS.,[3] new name for, and objective synonym of *Cyclotropis* Perner, 1903 (expl. pl. 61) and 1907 (p. 191), invalid homonym of *Cyclotropis* Tapp. Canefri, 1883. Cossmann, in 1909, (p. 67) recognizing the homonymy of *Cyclotropis* Perner, 1903, proposed the new name and objective synonym, *Eucyclotropis*, to replace it, being unaware that his new name was itself an invalid homonym of *Eucyclotropis* Jordan, 1904. Genotype *Cyclotropis docens* Barrande, MS., Perner, 1903 (expl. pl. 77) and 1907 (p. 193).

Burdikinia Knight, new name for, and objective synonym of *Polyamma* Etheridge, Jr., 1917 (p. 16), an invalid homonym of *Polyamma* Kriechbaumer, 1894. Genotype *Polyamma burdikinensis* Etheridge, Jr., 1917 (p. 16).

Episfaxis Perner MS.,[3] new name for, and objective synonym of *Cosmina* Perner, 1903 (expl. pl. 65) and 1907 (p. 296), an invalid homonym of *Cosmina* Robineau-Desvoidy, 1830. Genotype *Cosmina complacens* Barrande MS., Perner, 1903 (expl. pl. 65) and 1907 (p. 296).

Littorinides Knight, new name for, and objective synonym of *Rhadbopleura de* Koninck, 1881 (p. 75), an invalid homonym of *Rhabdopleura* Allman, 1869. Genotype *Monodonta solida* de Koninck, 1843 (p. 457).

Sosiospira Knight, new name for, and objective synonym of *Platychilus* [*Platycheilus*] Gemmellaro, 1889 (p. 139), an invalid homonym of *Platychilus* Cossmann, 1888, and Jakowlew, 1874. Genotype *Platychilus canaliculatum* Gemmellaro, 1889 (p. 140).

It seems hardly necessary to reemphasize the point that all of these proposed new names are objective synonyms of the preoccupied names replaced, and necessarily have as genotype the same species as the replaced name, whatever that species may be. In the above, I am citing as genotype in each case what I regard as the genotype of the preoccupied name. If I am in error on this point in any instance, the true genotype of the preoccupied name must serve as genotype of the new name as well, regardless of my erroneous citation of a different species. The references following each of the names replaced refer to the original proposal of the name and to a diagnosis or description of the genus.

INVALID GENERIC NAMES NOT REPLACED

The following invalid generic names are not replaced for the reasons given:

Orestes Girty, 1911 (p. 136) is an invalid homonym of *Orestes* Redtenbacher, 1906, and of Blakiston and Pryor, 1880. I have informed Doctor Girty of the facts, and he will replace *Orestes* with a new name in a forthcoming publication.

Raphistoma Hall, 1847 (p. 28) is an invalid homonym of *Raphistoma* Rafinesque, 1815, a name that has been almost entirely overlooked, and that appears to be a prior objective synonym of *Belone* Cuvier, 1817. If the Rules are rigidly enforced, the almost unknown *Raphistoma* Rafinesque would have to replace the well-known *Belone* Cuvier, and a new name would have to replace the equally well-known *Raphistoma* Hall. In association with others, I am petitioning the International Commission to suppress *Raphistoma* Rafinesque, 1815, under suspension of the Rules, and thus save both *Belone* Cuvier, 1817, and *Raphistoma* Hall, 1847. The case seems to be just the sort for which the plenary power was established, and it would

certainly be most unwise to replace *Raphistoma* Hall until the Commission has had an opportunity to act.

Agnesia de Koninck, 1883 (p. 99), an invalid homonym of *Agnesia* Michaelson, 1878. *Agnesia* de Koninck, 1883, appears to be a close subjective synonym of *Hesperiella* Holzapfel, 1889 (p. 54), and hence there is no need to replace it.

Catinella Stache, 1877 (p. 314), an invalid homonym of *Catinella* Pease, 1871, appears to be a subjective synonym of *Naticopsis* M'Coy, 1844 (p. 33), and therefore should not be replaced.

Coronilla Perner, 1907 (p. 13), an invalid homonym of *Coronilla* Beneden, 1871, appears to be a close subjective synonym of *Ruedemannia* Foerste, 1914 (p. 311), and hence there appears to be no need to replace it.

Glyptobasis de Koninck, 1881 (p. 92), is an invalid homonym of *Glyptobasis* McLachlan, 1871. As I pointed out in 1936, the genotype species of *Glyptobasis* de Koninck, *G. conica* de Koninck, is conspecific with *Cerithioides telescopium* Haughton, 1859, genotype of *Cerithioides* Haughton, 1859, and *Glyptobasis* de Koninck is thus a subjective-objective synonym of *Cerithioides* Haughton, 1859 (p. 282). As such, it should not be replaced.

Pileolus Spriesterbach, 1919 (p. 501), an invalid homonym of *Pileolus* Cookson MS., Sowerby, 1823, Lesson, 1831, and Ehrenberg, 1843, appears to be a close subjective synonym of *Palaeotrochus* Hall, 1879 (p. 133), and hence there seems to be no need to replace it.

Plectostylus Conrad, 1842 (p. 275), is an invalid homonym of *Plectostylus* Beck, 1837. However, it has long been recognized that the name has several subjective synonyms, among them *Strobeus* de Koninck, 1881 (p. 25), and *Sphaerodoma* Keyes, 1889 (p. 303), and it has very properly been allowed to lapse without replacement.

Portlockia de Koninck, 1881 (p. 81), as I have had occasion to point out before, is an invalid homonym of *Portlockia* M'Coy, 1846, and seemingly a close subjective synonym of *Yunnania* Mansuy, 1912 (p. 103). If the latter contention is sustained, there is no need for replacing it.

Rhabdospira Perner, 1903 (expl. pl. 75), is an invalid homonym of *Rhabdospira* Donald 1898, and as such must be suppressed. However, *Rhabdospira* Perner, 1903, is seemingly a subjective synonym of *Cyclotropis* Perner, 1903 (not *Cyclotropis* Tapp. Canefri, 1883, an objective synonym of *Eucyclotropis*, Cossmann, 1909, not *Eucyclotropis* Jordan, 1904, and of *Beraunia* Perner, MS., new name), as was pointed out by Perner, 1907 (p. 192). It is greatly to be hoped that no additional names will be proposed to further complicate this tangle. Certainly none is needed if the suggested synonymy with *Beraunia* is sustained.

Turbina de Koninck, 1881 (p. 69), an invalid homonym of *Turbina* Brown in Herrmannsen, 1847, seems to be a close subjective synonym of *Araeonema* Knight, 1933 (p. 40), and as such is not in need of replacement.

The following names have genotypes that are based on such very poor material that there seems to be no valid reason why the genera should have been erected in the first place, or the descriptions and figures were too poor to permit the species or its characters to be recognizable. In each case (except that of *Proboscidia* Merla) the type specimens are believed by their supposed conservators to be lost and irreplaceable. To replace any of these names with new and valid ones would, in my opinion, serve no useful end, unless and until new light can authentically be shed on their genotype species. In the meantime, it seems preferable to profit by their invalidity, and to al-

low them to rest unmolested in the obscurity they deserve. Our science would be well served if there were some way to be rid so easily of many other names which are nomenclatorally valid, but which are otherwise meaningless and a source of confusion alone. Invalid generic names that should not be replaced are:

Conchula Steininger, 1849 (p. 46), an invalid homonym of *Conchula* Herrmannsen, 1847.

Geinitzia Dietz, 1911 (p. 476), an invalid homonym of *Geinitzia* Gemmellaro, 1892, and Handlirsch, 1906.

Orthostoma Conrad, 1838 (p. 119), an invalid homonym of *Orthostoma* Audinet-Serville, 1834.

Proboscidia Merla, 1931 (p. 184), an invalid homonym of *Proboscidia* [*Proboskidia*] Bory, 1827.

I have made every effort to see that the facts on which this rather technical paper is based are correct, and that the lists of genera for which no genotypes have been fixed and of unreplaced homonyms are complete. I am keenly aware not only of the difficulties of this task but of my own fallibility, and will be very grateful for any corrections, since corrections at this time will enable me to correct the same errors in the comprehensive work on "Paleozoic Gastropod Genotypes" on which I am engaged.

REFERENCES

CONRAD, T. A., *1838, New York Geol. Survey, Ann. Rept.* 2, pp. 107–119.

———, *1842, Acad. Nat. Sci. Philadelphia, Jour.*, vol. 8, pt. 2, pp. 228–280, pls. 12–17.

COSSMANN, M., *1909, Rev. Critique Paléozoologie*, vol. 13.

DIETZ, E., *1911, Preuss. geol. Landesanstalt, Jahrb.*, vol. 30, pp. 444–506, pls. 13–15, 1909.

ETHERIDGE, R., JR., *1917, Queensland Geol. Survey, Pub.* 260, pp. 13–16, pl. 3, figs. 1, 2.

FOERSTE, A. F., *1914, Denison Univ. Sci. Lab., Bull.*, vol. 17, pp. 247–373, pls. 1–5.

GEMMELLARO, G. G., *1889*, La fauna dei Calcari con Fusulina della valle del fiume Sosio nella Provincia di Palermo, fasc. 2, pp. 97–182, pls. 11–19.

GIRTY, G. H., *1911, New York Acad. Sci., Annals*, vol. 21, pp. 119–156.

HALL, J., *1847, Paleontology of New York*, vol. 1.

———, *1879, Natural History of New York, Palaeontology*, 5, part 2.

HAUGHTON, S., *1859, Dublin Univ. Zool. and Bot. Assoc., Proc.*, vol. 1, pp. 281–283, pls. 20–21.

HOLZAPFEL, E., *1889, Palaeontologische Abhandlungen*, Bd. 5 (N. F. Bd. 1) Heft. 1.

KEYES, C. R., *1889, Acad. Nat. Sci. Philadelphia, Proc.*, pp. 303–309.

KNIGHT, J. B., *1933, Jour. Paleontology*, vol. 7, pp. 30–58, pls. 8–12.

KOBAYASHI, T., *1933, Tokyo Imp. Univ., Fac. Sci., Jour.*, sec. 2, vol. 3, pp. 249–328, pls. 1–10.

KOKEN, E., *1896, Die Leitfossilien*, Leipzig.

———, (ed. by J. Perner) *1925, Acad. Sci. Russie, Mem.*, ser. 8, Cl. Physico-Math., vol. 37, no. 1.

KONINCK, L. G. de, *1843*, Description des animaux fossiles, qui se trouvent dans le terrain Carbonifère de Belgique, Liége, 1842–44.

———, *1853, Soc. royale sci. Liége, Mém.*, ser. 1, vol. 8, pp. 140–144.

———, *1881, Mus. royale histoire nat. Belgique, Ann.*, sér. Paléontologique, t. 6.

———, *1883, Mus. royale histoire nat. Belgique, Ann.*, sér. Paléontologique, t. 8.

M'COY, F., *1844*, A synopsis of the characters of the Carboniferous limestone fossils of Ireland.

———, *1851, Annals and Mag. Nat. Hist.*, ser. 2, vol. 7, pp. 45–63.

MANSUY, H., *1912, Service geol. Indochine, Mém.*, vol. 1, fasc. 2, pt. 2, p. 103.

MEEK, F. B., and WORTHEN, A. H., *1861, Acad. Nat. Sci. Philadelphia, Proc.*, 1860, pp. 447–472.

MERLA, G., *1931, Padova R. Univ., Inst. Geol., Mem.*, vol. 9.

PERNER, J., *1900, Palaeontographica Bohemiae*, vol. 5, no. 5.

———, *1903*, in Barrande, J., Système silurien du centre de la Bohême, vol. 4, Gastéropodes. t. 1, text (Patellidae et Bellerophontidae) and pls. 1–89.

———, *1907*, in Barrande, J., Système silurien du centre de la Bohême, vol. 4, Gastéropodes. t. 2, text and pls. 90–175.

ROEMER, F. A., *1854, Palaeontographica*, vol. 3.

SPRIESTERBACH, J., *1919, Preuss. geol. Landesanstalt, Jahrb.* for 1917, Bd. 38, T. 1, pp. 434–512, pls. 24–39.

STACHE, G., *1877, Geol. Reischsanstalt, Jahrb.*, Bd. 27, Heft 1, pp. 271–318, pls. 1–3, 5–7.

STEININGER, J., *1849*, Jahresbericht ü. d. Schul-Cursus 1848–49 an dem Gymnasium zu Trier, von dem Director des Gymnasiums Dr. V. Loers.

ULRICH, E. O., *1897*, see Ulrich and Scofield, 1897. Scofield did not live to complete this work and some of the names proposed in it are claimed by Ulrich alone.

———, and SCOFIELD, W. H., *1897*, The Lower Silurian Gastropoda of Minnesota, in The Geology of Minnesota: *Minnesota Geol. and Nat. Hist. Survey, Final Rept.*, vol. 3, pt. 2, pp. 813–1081, pls. 61–82.

WHIDBORNE, G. F., *1891*, A monograph of the Devonian fauna of the south of England, vol. 1, The fauna of the limestones of Lummaton, Wolborough, Chircombe Bridge, and Chudleigh, pp. 155–250: *Palaeont. Soc. London*, 1889–92.

J. BROOKES KNIGHT, PRINCETON UNIVERSITY, PRINCETON, N. J. MANUSCRIPT RECEIVED BY THE EDITOR, SEPTEMBER, 1937.

PALEONTOLOGICAL NOTES

TEXTULARIA HOCKLEYENSIS VAR. *MALKINAE* CORYELL AND EMBICH, A NEW NAME FOR *TEXTULARIA HOCKLEYENSIS* VAR. *PANAMENSIS* CORYELL AND EMBICH

H. N. CORYELL

Miss Doris Malkin has called our attention to the fact that the variety name of *Textularia hockleyensis* var. *panamensis* Coryell and Embich, 1937, *Jour. Paleontology*, vol. 11, no. 4, p. 295, is preoccupied according to Article 11 of the *Rules of Zoological Nomenclature*, by *Textularia panamensis* Cushman, 1918, *U. S. Nat. Mus., Bull.* 103, p. 53. The name *Textularia hockleyensis* var. *malkinae* is proposed here in order to make this correction.

JOURNAL OF PALEONTOLOGY

INDEX TO VOLUME 11

AUTHOR INDEX

	No.	Page
1. ALBRITTON, CLAUDE C., JR., Upper Jurassic and Lower Cretaceous Foraminifera from the Malone Mountains, Trans-Pecos, Texas	(1)	19
2. ———, and PHLEGER, FRED B., JR., Foraminiferal zonation of certain Upper Cretaceous clays of Texas	(4)	347
See also Okulitch, Vladimir J., and Albritton, C. C.		
3. BASSLER, R. S., The Paleozoic rugose coral family Paleocyclidae	(3)	189
BERMUDEZ, P. J., see PARKER, F. L. and BERMUDEZ, P. J.		
4. BERRY, CHARLES T., An ophiuran from the Byram marl (Oligocene) of Mississippi	(3)	235
See also HOFFMEISTER, WILLIAM S., and BERRY, C. T.		
BRAMKAMP, R. A., see DURHAM, J. WYATT		
5. BRANSON, C. C., Stratigraphy and fauna of the Sacajawea formation, Mississippian, of Wyoming	(8)	650
BROOM, ROBERT, see OLSON, E. C., and BROOM, R.		
6. BUCK, JOHN B., A Miocene clam that lived in a barnacle shell	(7)	624
CHURCH, C. C., see HANNA, G. D., and CHURCH, C. C.		
7. CLARK, HUBERT LYMAN, A new Eocene sea-urchin from Albama	(3)	248
8. CLINE, L. M., Blastoids of the Osage group, Mississippian: Part II. The genus *Cryptoblastus*	(8)	634
9. COLLINS, R. LEE, Growth stages of Mexican Tertiary caecids	(1)	31
COOPER, G. ARTHUR, see ULRICH, E. O., and COOPER, G. A.		
10. CORYELL, H. N., *Textularia hockleyensis* var. *malkinae* Coryell and Embich, a new name for *Textularia hockleyensis* var. *panamensis* Coryell and Embich	(8)	714
11. ———, and EMBICH, JOHN R., The Tranquilla shale (upper Eocene) of Panama and its foraminiferal fauna	(4)	289
12. DURHAM, J. WYATT, Gastropods of the family Epitoniidae from Mesozoic and Cenozoic rocks of the West Coast of North America, including one new species by F. E. Turner and one by R. A. Bramkamp	(6)	479
13. ———, *Operculina* in the Lower Tertiary of Washington	(4)	367
14. ELIAS, MAXIM K., A new scorpion from the Pennsylvanian *Walchia* beds near Garnett, Kansas	(4)	335
15. ———, Stratigraphic significance of some Late Paleozoic fenestrate bryozoans	(4)	306
ELLIS, A. D., JR., see GARRETT, J. B., and ELLIS, A. D., JR.		
EMBICH, J. R., see CORYELL, H. N., and EMBICH, J. R.		
FOSTER, C. L., see THOMPSON, M. L., and FOSTER, C. L.		
16. FRITZ, MADELEINE A., *Multisolenia*, a new genus of Paleozoic corals	(3)	231
FURNISH, W. M., See MILLER, A. K., and FURNISH, W. M.		
17. GARRETT, J. B., and ELLIS, A. D., JR., Distinctive Foraminifera of the genus *Marginulina* from Middle Tertiary beds of the Gulf Coast	(8)	629
18. GIRTY, GEORGE H., Three Upper Carboniferous gastropods from New Mexico and Texas (errata 5, p. 476)	(3)	202
19. GRAVELL, DONALD W., and HANNA, MARCUS A., The *Lepidocyclina texana* horizon in the *Heterostegina* zone, upper Oligocene, of Texas and Louisiana	(6)	517
20. HANNA, G. D., and CHURCH, C. C., Notes on *Marginulina vacavillensis* (Hanna)	(6)	530
See also GRAVELL, D. W., and HANNA, M. A.		
21. HANZAWA, SHOSHIRO, Notes on some interesting Cretaceous and Tertiary Foraminifera from the West Indies	(2)	110
22. HAZEN, B. M., A fossil earthworm (?) from the Paleocene of Wyoming	(3)	250
23. HEDBERG, H. D., Foraminifera of the Middle Tertiary Carapita formation of northeastern Venezuela	(8)	661
24. HENBEST, LLOYD G., Keriothecal wall-structure in *Fusulina* and its influence on fusuline classification	(3)	212

		No.	Page
25.	HOFFMEISTER, WILLIAM S., and BERRY, CHARLES T., A new genus of Foraminifera from the Miocene of Venezuela and Trinidad	(1)	29
26.	HOWE, HENRY V., Large oysters from the Gulf Coast Tertiary	(4)	355
27.	IMLAY, RALPH W., Lower Neocomian fossils from the Miquihuana region, Mexico	(7)	552
28.	JAMES, MAURICE T., A preliminary review of certain families of Diptera from the Florissant Miocene beds	(3)	241
29.	JOHNSTON, C. STUART, Notes on the craniometry of *Equus scotti* Gidley	(5)	459
30.	KELLETT, BETTY, Carboniferous ostracodes (a correction)	(1)	80
	KEROHER, R. P., see NEWELL, N. D., and KEROHER, R. P.		
31.	KIRK, EDWIN, *Eupachycrinus* and related Carboniferous crinoid genera	(7)	598
32.	KNIGHT, J. BROOKES, *Conchopeltis* Walcott, an Ordovician genus of the Conulariidae	(3)	186
33.	———, Genotype designations and new names for invalid homonyms among Paleozoic gastropod genera	(8)	709
34.	LAUDON, L. R., New occurrence of the Upper Carboniferous crinoid genera *Amphicrinus* and *Synerocrinus*	(8)	706
35.	MCGREW, PAUL O., The genus *Cynarctus*	(5)	444
	MALOTT, C. A., see PAYNE, KENNETH ARMSTRONG		
36.	MANSFIELD, W. C., New mollusks from the Choctawhatchee formation of Florida	(7)	608
37.	MILLER, A. K., and FURNISH, W. M., Ordovician cephalopods from the Black Hills, S. Dak.	(7)	535
38.	———, and OWEN, JOHN BRITTS, A new Pennsylvanian cephalopod fauna from Oklahoma	(5)	403
39.	NEWELL, NORMAN D., and KEROHER, RAYMOND P., The fusulinid, *Wedekindellina*, in Mid-Pennsylvanian rocks of Kansas and Missouri	(8)	698
40.	OKULITCH, VLADIMIR J., Some changes in nomenclature of Archaeocyathi (Cyathospongia)	(3)	251
41.	———, and ALBRITTON, CLAUDE C., JR., *Malonophyllum*, a new tetracoral from the Permian of Texas	(1)	24
42.	OLSON, EVERETT CLAIRE, and BROOM, ROBERT, New genera and species of tetrapods from the Karroo beds of South Africa	(7)	613
43.	OMAN, PAUL W., Fossil Hemiptera from the Fox Hills sandstone (Cretaceous) of Colorado	(1)	38
	OWEN, JOHN B., see MILLER, A. K., and OWEN, J. B.		
44.	PARKER, F. L., and BERMUDEZ, P. J., Eocene species of the genera *Bulimina* and *Buliminella* from Cuba	(6)	513
45.	PAYNE, KENNETH ARMSTRONG, Pennsylvanian Ostracoda from Sullivan County, Indiana	(4)	276
46.	PECK, RAYMOND E., Morrison Charophyta from Wyoming	(2)	83
47.	PHLEGER, FRED B., JR., Further notes on the Lichadacea	(3)	253
	See also ALBRITTON, C. C., JR., and PHLEGER, F. B., JR.		
48.	POPENOE, WILLIS PARKISON, Upper Cretaceous Mollusca from southern California	(5)	379
49.	RATHBUN, MARY J., Cretaceous and Tertiary crabs from Panama and Colombia	(1)	26
50.	RAW, FRANK, Systematic position of the Olenellidae (Mesonacidae)	(7)	575
51.	REINHART, PHILIP W., Cretaceous and Tertiary pelecypods of the Pacific Slope incorrectly assigned to the family Arcidae	(3)	169
52.	———, Three new species of the pelecypod family Arcidae from the Pliocene of California	(3)	181
53.	RESSER, CHARLES E., Elkanah Billings' Lower Cambrian trilobites and associated species	(1)	43
54.	———, New species of Cambrian trilobites of the family Conocoryphidae	(1)	39
	RICHARDS, H. G., see WHITCOMB, LAWRENCE, and RICHARDS, H. G.		
55.	ROBERTSON, GEO. M., Anaspida from the Ludlow of Oesel	(3)	256
56.	SCOTT, GAYLE, Ammonites of the genera *Sonneratia* and *Douvilleiceras* from the Cretaceous of Colombia	(1)	34
57.	SIMPSON, GEORGE GAYLORD, *Unuchinia*, new name for Apator Simpson, not Semenow	(1)	78
58.	STANTON, T. W., The genotype of *Mortoniceras* Meek	(5)	456
59.	STAUFFER, CLINTON R., A diminutive fauna from the Shakopee dolomite (Ordovician) at Cannon Falls, Minn.	(1)	55

		No.	Page
60.	———, Mollusca from the Shakopee dolomite (Ordovician) at Stillwater, Minn.	(1)	61
61.	STEPHENSON, MORTON B., Middle Tertiary Ostracoda of the genus *Cytheridea*.	(2)	145
62.	STEWART, GRACE A., *Aechmina crenulata*, new name for *Aechmina serrata* Stewart, not Coryell and Cuskley	(4)	68
63.	STOVALL, J. WILLIS, *Euceratherium bizzelli*, a new ungulate from Oklahoma	(5)	450
64.	STUMM, ERWIN C., The Lower Middle Devonian tetracorals of the Nevada limestone	(5)	423
65.	THIADENS, A. A., Cretaceous and Tertiary Foraminifera from southern Santa Clara province, Cuba	(2)	91
66.	Thomas, Horace D., *Plicatoderbya*, a new Permian brachiopod subgenus	(1)	13
67.	THOMPSON, M. L., Fusulinids of the subfamily Schubertellinae	(2)	118
68.	———, and FOSTER, C. L., Middle Permian fusulinids from Szechuan, China	(2)	126
69.	TOLMACHOFF, I. P., *Cooperatia*, new name for *Cooperia* Tolmachoff, not Ransom	(1)	78
	TURNER, F. E., see DURHAM, J. WYATT		
70.	ULRICH, EDWARD O., and COOPER, G. ARTHUR, *Cambrotrophia*, new name for *Eostrophia* Ulrich and Cooper, not Dall	(1)	78
71.	VAUGHAN, THOMAS WAYLAND, Marshall Avery Howe	(4)	368
72.	VERMUNT, L. W. J., Cretaceous rudistids of Pinar del Rio province, Cuba	(4)	261
73.	VOKES, H. E., Nautiloid cephalopods from the Eocene of California (errata 3, p. 257)	(1)	3
74.	———, The gastropod genus *Harpa* in the Eocene of western United States	(1)	10
75.	WARREN, P. S., An Aptian horizon in the Cretaceous of the Lower Mackenzie Valley	(1)	69
76.	WEIKERT, ROSALIE, Bibliography of papers by Marshall Avery Howe on calcareous algae	(4)	369
77.	WELLER, J. MARVIN, Evolutionary tendencies in American Carboniferous trilobites	(4)	337
78.	WELLS, JOHN W., New genera of Mesozoic and Cenozoic corals	(1)	73
79.	WEST, C. D., Note on the crystallography of the echinoderm skeleton	(5)	458
80.	WHITCOMB, LAWRENCE, and RICHARDS, HORACE G., A fossiliferous marine clay near Yamouth, Maine	(3)	252
81.	WILLARD, BRADFORD, *Taeniaster* in Pennsylvania	(7)	620
82.	WILLIAMS, LOU, A study of *Neuropteris schlehani* Stur	(5)	462

SUBJECT INDEX

(Numbers given in following index refer to papers as listed in foregoing author index.)

Africa: Karroo tetrapods (42).
Alabama: Tertiary echinoid (7); Tertiary ostracodes (61).
Algae: bibliography (76).
Anaspida: Silurian, Oesel (55).
Annelida: Mississippian, Wyoming (5).
Aptian: Cretaceous, Lower Mackenzie Valley (75).
Archaeocyathi (Cyathospongia): (40).

Blastoids: Mississippian (8).
Brachiopods: *Plicatoderbya* (66); *Cambrotrophia* (70); Mississippian, Wyoming (5); Permian (66); Cretaceous, Mexico (27).
British Columbia: pelecypods, Cretaceous, Tertiary (51).
Bryozoans: Mississippian, Wyoming (5); Late Paleozoic, stratigraphic significance (15).
By-laws, Society of Economic Paleontologists and Mineralogists, vol. 4, p. 374.

California: Mollusca, Cretaceous (48); pelecypods, Arcidae, Cretaceous, Tertiary (51); Arcidae, Pliocene (52); gastropods, Epitoniidae, Mesozoic, Cenozoic (12), *Harpa*, Eocene (74); cephalopods, Eocene (73).
Cambrian: trilobites (50, 53, 54); Olenellidae (50); Conocoryphidae (54).
Canada: Aptian horizon, Cretaceous Mackenzie Valley (75).
Carboniferous: see crinoids, gastropods, trilobites, ostracodes.
Cenozoic: corals (78); gastropods, Epitoniidae (12).
Cephalopods: Ordovician, South Dakota (37), Minnesota (59, 60); Pennsylvanian, Oklahoma (38); Cretaceous, *Mortoniceras* (58), Canada (75), Colombia (56), Mexico (27); Tertiary, California (73).

Charophytes: Morrison, Wyoming (46).
China: Permian fusulinids (68).
Colombia: Cretaceous ammonites (56); Cretaceous crab (49).
Colorado: Insects, Cretaceous (43), Tertiary (28).
Conchopeltis: Ordovician conularid (32).
Conocoryphidae: Cambrian (54).
Constitution, Society Economic Paleontologists and Mineralogists, vol. 4, p. 373.
Conularid: *Conchopeltis*, Ordovician (32).
Cooperatia: new name for *Cooperia* (69).
Corals: Paleozoic, Paleocyclidae (3), *Multisolenia* (16); Devonian, Nevada (64); Permian, *Malonophyllum*, Texas (41); Mesozoic and Recent (78).
Cretaceous: Foraminifera, Cuba (65), Texas (1, 2), West Indies (21); rudistics, Cuba (72); Mollusca, California (48); brachiopods, Mexico (27); pelecypods, so-called Arcidae (51), Mexico (27); cephalopods, Colombia (56), Mexico (27); crabs, Colombia (49); insects, Colorado (43); Aptian horizon, Mackenzie Valley (75).
Crinoids: Carboniferous, *Eupachycrinus* (31), *Amphicrinus*, *Synerocrinus* (34).
Crustaceans: crabs, Cretaceous and Tertiary (49).
Cryptoblastus: blastoid, Mississippian (8).
Cuba: Foraminifera, Cretaceous, Tertiary (65), Eocene (44); rudistids, Cretaceous (72).
Cynarctus: (35).
Cytheridea: Tertiary, Gulf Coast (61).

Devonian: corals, Nevada (64).
Diptera: Miocene, Colorado (28).
Douvilleiceras: Cretaceous, Colombia (56).

Echinoderms: Mississippian, Wyoming (5); crystallography of skeleton (79). (See blastoids, crinoids, echinoids, ophiuroids).
Echinoids, Eocene, Alabama (7).
Eocene: (see Foraminifera, echinoids, gastropods, cephalopods).
Epitoniidae: gastropods, Mesozoic, Cenzoic (12).
Equus scotti: craniometry (29).
Eucratherium bizzelli: ungulate, Oklahoma (63).
Eupachycrinus: crinoid, Carboniferous (31).

Florida: Choctawhatchee mollusks (36).
Florissant: Miocene, Diptera (28).
Foraminifera: Carboniferous, *Fusulina* (24), Schubertellinae (67), *Wedekindellina*, Kansas, Missouri (39); Permian (67), China (68); Jurassic, Cretaceous, Texas (1); Cretaceous, Tertiary, Cuba (65), Texas (2), West Indies (21); Tertiary, Eocene, *Bulimina*, *Buliminella*, Cuba (44), Panama(10, 11), *Marginulina*, Gulf Coast (17), *Marginulina vacavillensis* (20), Miocene, Venezuela, Trinidad (25), *Operculina*, Washington (13), Venezuela (23), Oligocene, *Lepidocyclina texana* in *Heterostegina* zone, Texas, Louisiana (19).
Fucoid: Ordovician, Minnesota (60).
Fusulinids: see Foraminifera.

Gastropods: Paleozoic (33); Ordovician, Minnesota (59, 60); Mississippian, Wyoming (5); Carboniferous, New Mexico, Tertiary (18); Cretaceous, California (48); Eocene, *Harpa* (74); Miocene, Florida (36); Mesozoic and Cenozoic, West Coast (12); Tertiary, Mexico (9).
Gulf Coast: oysters (26).

Harpa: Eocene (74).
Hadyden Branch: Indiana (45).
Hemiptera: Cretaceous, Colorado (43).
Heterostegina: Oligocene, Texas, Louisiana (19).
Howe, Marshall Avery: (71).

Indiana: Pennsylvanian ostracodes (45).
Insects: Hemiptera, Cretaceous, Colorado (43): Diptera, Miocene, Colorado (28).
Iowa: blastoids, Mississippian (8).

Jurassic: Foraminifera, Texas (1).

Kansas: Pennsylvanian, fusulinid *Wedekindellina* (39), scorpion (14).
Karroo: tetrapods, South Africa (42).

Labrador: Cambrian trilobites (53).
Lepidocyclina texana: Oligocene, Texas, Louisiana (19).
Lichadacea: (47).
Louisiana: Foraminifera, *Lepidocyclina texana*, Oligocene (19), *Marginulina*, Tertiary (17); ostracodes, *Cytheridea*, Tertiary (61).

Maine: (80).
Malonophyllum: coral, Permian, Texas (41).
Mammals: *Cynarctus*, Miocene (35); *Equus scotti*, craniometry (29); *Euceratherium bizzelli*, ungulate, Oklahoma (63); *Unuchinia*, Paleocene (57).
Marginulina: Tertiary, Gulf Coast (17); *vacavillensis* (20).
Mesozoic: see Charophyta, Foraminifera, corals, gastropods.
Mexico: Cretaceous fossils (27); Tertiary caecids (9).
Minnesota: Ordovician fauna (59, 60).
Miocene: see Foraminifera, pelecypods, insects, mammals.
Mississippi: Tertiary, Ostracodes, *Cytheridea* (61); Oligocene, ophiuran (4).
Mississippian: blastoids, *Cryptoblastus* (8); Wyoming (5).
Missouri: Pennsylvanian fusulinid *Wedekindellina* (39); Mississippian blastoids (8).
Mortoniceras: genotype (58).
Multisolenia: Paleozoic corals (16).

Murphys Bluff: Pennsylvanian formation, Indiana (45).
Nebraska: *Cynarctus* (35).
New Mexico: gastropods, Carboniferous (18).
Norway: Anaspida, Ludlow (55).
Neuropteris schlehani: (82).
Nevada: tetracorals, Devonian (64).

Oklahoma: Carboniferous crinoids *Amphicrinus*, *Synerocrinus* (34); Pennsylvanian cephalopod (38); ungulate, *Euceratherium bizzelli* (63).
Olenellidae: (50).
Oligocene: see Foraminifera, ophiuran.
Operculina: Tertiary, Washington (13).
Ophiuran: Oligocene, Mississippi (4).
Ordovician: see conularid, fucoid, gastropods, cephalopods, trilobites, stelleroid.
Oregon: Gastropods, Mesozoic, Cenozoic (12).
Osage: blastoids, *Cryptoblastus* (8).
Ostracodes: *Aechmina crenulata* (62), *Cooperatia* (69); *Cytheridea* (61); Mississippian, Wyoming (5); Pennsylvanian, Indiana (45); Carboniferous (30); Tertiary, *Cytheridea* (61).
Oysters: Tertiary, Gulf Coast (26).

Paleocene: earthworm, Wyoming (22).
Paleocyclidae: Paleozoic corals (3).
Paleozoic: see corals, bryozoans, gastropods.
Panama: Foraminifera, Eocene (10, 11); crabs, Tertiary (49).
Pelecypods: Mississippian, Wyoming (5); Cretaceous, California (48), Mexico (27); Cretaceous and Tertiary, so-called Arcidae (51), Gulf Coast (26); Miocene, Florida (36); Pliocene, Arcidae, California (52); living in barnacle (6).
Pennsylvanian: see Foraminifera, cephalopods, ostracodes, stelleroid, scorpion.
Permian: see Foraminifera, corals, brachiopods.
Plants: Charophyta, Wyoming (46); *Neuropteris schlehani* (82).
Pleistocene: Maine (8). (See Mammals.)
Plicatoderbya: Permian brachiopod (66).
Pliocene: pelecypod Arcidae, California (52).

Reptiles: Karroo tetrapods, South Africa (42).
Rudistids: Cretaceous, Cuba (72).

Schubertellinae: fusulinids (67).
Scorpion: Pennsylvanian, Kansas (14).
Sonneratia: Cretaceous, Colombia (56).
South Dakota: Ordovician cephalopods (37).
Sponges: Mississippian, Wyoming (5); Archaeocyathi (Cyathospongia) (40).
Stelleroid: Ordovician, Pennsylvania (81).
Synerocrinus: Carboniferous crinoid (34).

Taeniaster: Ordovician, Pennsylvania (81).
Tertiary: see Foraminifera, ophiuran, pelecypods, gastropods, ostracodes, crab.
Tetrapods: Karroo, South Africa (42).
Texas: Jurassic and Cretaceous (1), Cretaceous (2), Oligocene, *Lepidocyclina texana* (19), Tertiary, *Marginulina* (17); coral, Malonophyllum, Permian (41); gastropod, Permian (18)
Trilobites: Conocoryphidae (54); Lichadacea (47); Olenellidae (50); Cambrian (53, 54); Ordovician, Minnesota (59); Mississippian, Wyoming (5); Carboniferous (77).
Trinidad: Miocene Foraminifera (25).
Trochiliscids: Morrison, Wyoming (46).

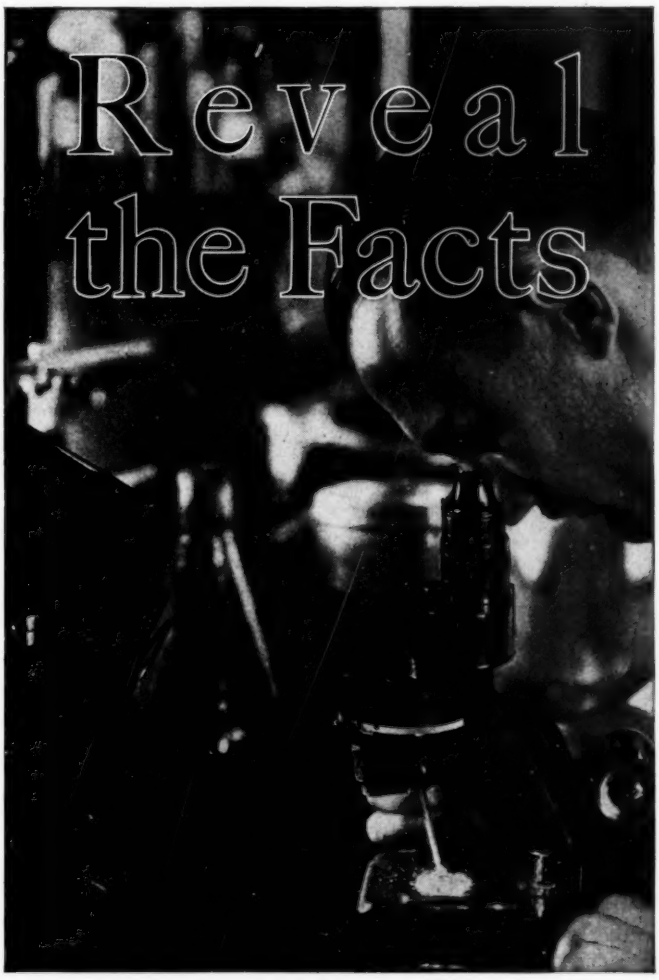
Ungulate: *Euceratherium bizzelli*, Oklahoma (63).
Unuchinia: (57).

Venezuela: Tertiary Foraminifera (23, 25).
Vermes: earthworm (?), Paleocene, Wyoming (22).
Vermont: Cambrian trilobites (53).

Walchia beds: scorpion, Kansas (14).
Washington: Foraminifera, Tertiary, *Operculina* (13); pelecypods, Cretaceous, Tertiary (51); Gastropods, Mesozoic, Cenozoic, Epitoniidae (12), Eocene, *Harpa* (74).
Wedekindellina: Pennsylvanian, Kansas, Missouri (39).
West Indies: Foraminifera, Cretaceous, Tertiary (21).
Wyoming: Charophyta, Morrison (46); Paleocene earthworm (?) (22); Mississippian stratigraphy, fauna (5).

A VIVID STEREOSCOPIC IMAGE

to Reveal the Facts



● For study—inspection — analysis — dissection, at magnifications of 3.6 to 210, the Spencer low-power binocular microscopes enhance human vision, producing a vivid stereoscopic image — an erect image not inverted and reversed as in a regular laboratory microscope.

A variable interpupilary distance and the natural 8° convergence of the eyepiece tubes assure the comfort of the observer. The 16° convergence of the objectives increases the usual stereoscopic effect.

Paired parfocal objectives revolve in a dust-tight drum. A large 100 mm. square, plate glass stage (removable) provides for handling large specimens.

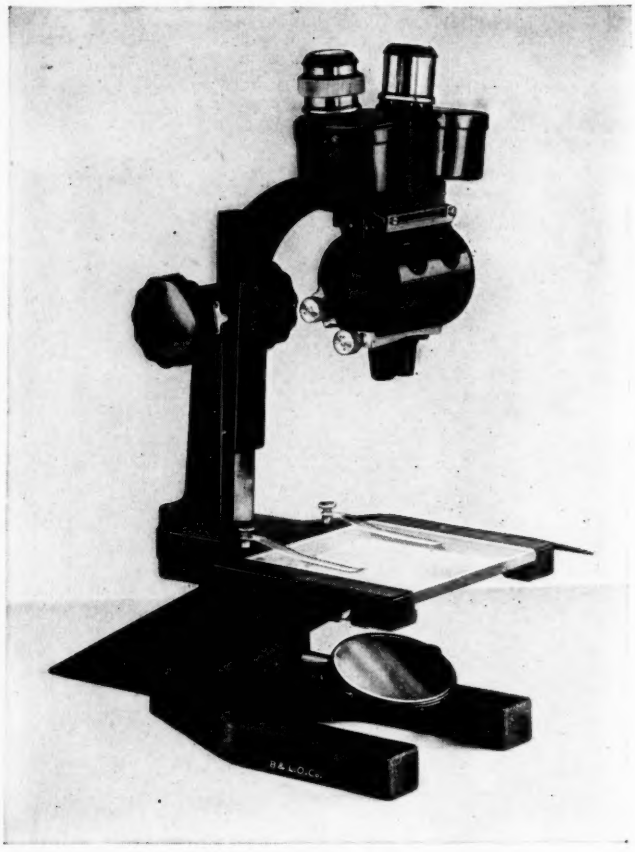
Write for folder M-67. Please address, Dept. D-7-12

Spencer Lens Company

MICROSCOPES
MICROTOMES
PHOTOMICROGRAPHIC EQUIPMENT

SPENCER BUFFALO U.S.A.

REFRACTOMETERS
COLORIMETERS
SPECTROMETERS
PROJECTORS



EVERY QUALIFICATION—
FOR LABORATORY OR FIELD USE

B & L Wide Field Binocular Microscopes fill every requirement for low power work of any nature in the laboratory, with accuracy, precision and dependability.

Their unusually rugged and trouble proof construction enables them to withstand the severe service of field work without impairment of either efficiency or smooth trouble free operation.

B & L Wide Field Binocular Microscopes show an erect and unreversed image in three dimensions. They have a wider field of view with a longer working distance, permitting the easy examination of large and irregularly shaped objects. A patented drum nosepiece permits rapid interchange of objectives without refocusing. Magnifications range from 3.9X to 150X. A substantially constructed carrying case is available for field use. For complete information write for Catalog D-15 to Bausch & Lomb Optical Co., 647 St. Paul St., Rochester, N.Y.

BAUSCH & LOMB

....WE MAKE OUR OWN GLASS TO INSURE STANDARDIZED PRODUCTION

FOR YOUR GLASSES INSIST ON B & L ORTHOGON LENSES AND B & L FRAMES...

OFFICERS OF THE SOCIETIES

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

For the year ending March, 1938

President, S. G. WISSLER, Compton, California.

Past-President, MERLE C. ISRAELSKY, Houston, Texas.

Vice-President, F. W. ROLSHAUSEN, Houston, Texas.

Secretary-Treasurer, H. V. HOWE, Baton Rouge, Louisiana.

Editor, RAYMOND C. MOORE, Lawrence, Kansas.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

For the year ending March, 1938

President, H. B. FUQUA, Fort Worth, Texas.

Past-President, RALPH D. REED, Los Angeles, California.

Vice-President, C. L. MOODY, Shreveport, Louisiana.

Secretary-Treasurer, I. H. CRAM, Tulsa, Oklahoma.

Editor, W. A. VER WIEBE, Wichita, Kansas.

Business Manager, J. P. D. HULL, Tulsa, Oklahoma.

Society Headquarters, 608 Wright Bldg., Tulsa, Oklahoma.

PALEONTOLOGICAL SOCIETY

For the year ending December, 1937

President, J. A. CUSHMAN, Sharon, Massachusetts.

Vice-President, C. G. CRONEIS, Chicago, Illinois.

Secretary, B. F. HOWELL, Princeton, New Jersey.

Treasurer, C. O. DUNBAR, New Haven, Connecticut.

Editor, C. WYTHE COOKE, Washington, D.C.

GEOLOGICAL SOCIETY OF AMERICA

For the year ending December, 1937

President, CHARLES PALACHE, Cambridge, Massachusetts.

Past-President, W. C. MENDENHALL, Washington, D. C.

Vice-President, W. O. HOTCHKISS, Troy, New York.

Vice-President, CHARLES CAMSELL, Ottawa, Canada.

Vice-President, G. D. HARRIS, Ithaca, New York.

Vice-President, W. S. BAYLEY, Urbana, Illinois.

Secretary, C. P. BERKEY, New York, New York.

Treasurer, E. B. MATHEWS, Baltimore, Maryland.

Society Headquarters, 419 West 117th St. New York, New York.